An Integrated Conceptual Model of 360-Degree Performance Appraisal and Candidate Forecasting Using Adaptive Neuro-Fuzzy Inference System

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Abstract

360-degree evaluations are popular performance appraisal method that involves evaluation input from multiple levels within the firm as well as external sources. However, subordinate can be bias the ratings. The performance appraisal process is far from accurate and objective, sometimes resulting in rating errors. This article proposes an approach to minimizing subjective judgement in the effective employee evaluation in the existence of the multi-factor competency-based measures in a hierarchical structure using ANFIS and ANOVA algorithm. This study supports the ideas that the best MSE (0.0056) calculation is achieved by Using Adaptive Neuro-Fuzzy Inference System (ANFIS) with ANOVA selection features. The method suggested helps Human Resource (HR) managers to make more objective decisions for put right man on right time. The predicting behavioural competencies of employees to make investment in human development more effective. It is also a change in the decision-making concept of Human Resource Development (HRD) from feelings about the decision based on more information.

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1 Introduction

Employees are considered as a strategic asset for the organization, and could determine the organization's survival (Drucker, 1994). The performance appraisal system (PAS) is important as a management tool to assess employees' efficiency in the workplace [1]. The performance appraisal (PA) is a formal and systematic process of identifying, observing, measuring, recording and developing the job-relevant strengths and weaknesses of employees. Chen and Kuo (2004) characterize PA as an indispensable process for an organization. Fletcher (2001) posits that the PA has a strategic approach and integrates organizational policies and human resource activities.

Everyone has biases, it's completely normal. Performance appraisal is the systematic observation and evaluation of employee's performance. Some of the most commonly used performance appraisal methods include the judgmental approach, the absolute standards approach, and the results-oriented approach. Ideally, performance appraisal should be completely accurate and objective. However, the performance appraisal process is far from accurate and objective, sometimes resulting in rating errors. Common rating errors include strictness or leniency, central tendency, halo effect, and recency of events [2].

It's natural to have biases, human resource management professional should understand how to conduct a performance review fairly and impartially. It's important to give everyone a fair performance review. However, in a professional situation like a performance review, Human resource management professional must practice fair judgment for every employee.

There several methods and techniques used for evaluating employees performance. These may be classified into two broad categories as stated by C.B. Gupta [3].

1.1 Traditional Methods

Traditional Methods are relatively older methods of performance appraisals. This method is based on studying the personal qualities of the employees. It may include knowledge, initiative, loyalty, leadership and judgment.

1.2 Modern Methods

Modern Methods were devised to improve the traditional methods. It attempted to improve the shortcomings of the old methods such as biasness, subjectivity, etc. This method has been used for appraisal of managers and specialists. The objectives and plans which should be completed by the employee by the deadline are appraised. These objectives are measurable and should be S.M.A.R.T [4].

About the S.M.A.R.T that, the November 1981 issue of Management Review contained a paper by George T. Doran called There's a S.M.A.R.T. way to write management's goals and objectives. It discussed the importance of objectives and the difficulty of setting them. Ideally speaking, each corporate, department, and section objective should be:

- Specific – target a specific area for improvement
- Measurable – quantify or at least suggest an indicator of progress
- Assignable – specify who will do it
- Realistic – state what results can realistically be achieved, given available resources
- Time-related – specify when the result(s) can be achieved

A key part of its value is that S.M.A.R.T. prompts people into the act of clearly considering and defining goals and objectives as they set them. This reduces the risk of creating a vague or unclear goal that is unlikely to be achieved. The appraisal reviews fulfilment of the objectives, necessary improvements and it sets up new objectives for the next period.

360-degree performance appraisal are in the modern method. The method may be any person who through knowledge about the job has done by contents to be appraised. Standards of contents and who is observes the employee while performing a job. The 360-degree feedback is understood as systematic collection of performance data on an individual or group, derived from several stakeholders-the stakeholders being the immediate supervisors, team members, customers, peers and self. The performance appraisal 360° feedback evaluation scheme as shown in Figure 1.

360-degree evaluations are the latest approach to evaluating performance. It is a popular performance appraisal method that involves evaluation input from multiple levels within the firm as well as external sources [5]. In a special edition of Human Resource Management on 360-degree feedback, Tornow [6] observes that in 360-degree feedback programs, feedback about a target individual is solicited from significant others using a standardized

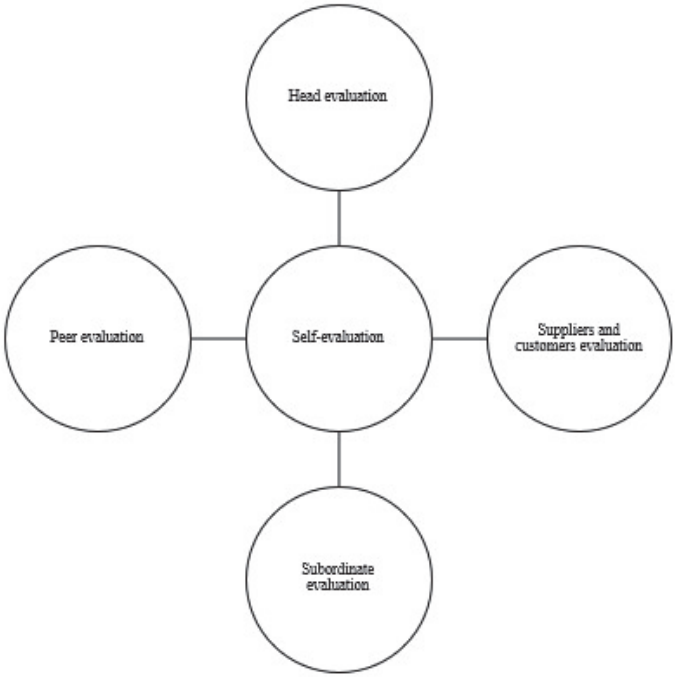

Figure 1 The performance appraisal 360° feedback evaluation scheme.

instrument. Jones and Bearley [7] refer to 360-degree feedback as the practice of gathering and processing multi-rater assessments on individuals and feeding back the results to the recipients. Hoffman [8] explains that 360-degree feedback is an approach that gathers behavioural observations from many layers within the organization and includes self-assessment. The 360-degree evaluation can help one person be rated from different sides, different people which can give the wider prospective of the employee's competencies [9]. It has been used for human resource development, appraisal and pay decisions [1]. 360 degree is an appraisal tool that incorporates feedback from multi- source, in order to give the employee a clear picture of his greatest overall strengths and weaknesses also it is a more objective and fair process.

Ideally, performance appraisals should be based on data collected about a subordinate's performance over an entire evaluation period (usually six months to a year). However, as is often the case, the supervisor is likely to consider recent performance more strongly than performance behaviours that occurred earlier. This is called the recency of events error. Failure to include

all performance behaviours in the performance appraisal of a subordinate can bias the ratings. Challenge of performance appraisal system that Walters (1995) outline the main Performance Appraisal challenges in the performance appraisal process:

- Determining the evaluation criteria. Identification of the appraisal criteria is one of the biggest problems faced by the top management. For the purpose of evaluation, the criteria selected should be in quantifiable or measurable terms.
- Lack of competence. Evaluators should have the required expertise and the knowledge to decide the criteria accurately. They should have the experience and the training necessary to carry out the appraisal process objectively.
- Errors in rating and evaluation. Many errors based on the personal bias like stereotyping, halo effect (i.e. one trait influencing the evaluator's rating for all other traits) etc. may creep in the appraisal process. Therefore, the rater should exercise objectivity and fairness in evaluating and rating the performance of the employees.
- Resistance. The appraisal process may face resistance from the employees because of the fear of negative ratings. Therefore, the employees should be communicated and clearly explained the purpose as well the process of appraisal. The standards should be clearly communicated, and every employee should be made aware of what exactly is expected from them.

This is a common bias and is known as the halo effect [3]. The manager's positive perception of an employee can cloud their judgment and cause them to overlook how the employee can improve. This, in turn, affects the objectivity of the employee's performance review. Therefore 360 feedback assessment tools are important in conducting fair performance reviews. These tools allow multiple sources, such as colleagues and managers, to assess an employee's performance. Instead of relying on one person's perspective, they will get a full picture of an employee's performance from the reviews of others [2]. However, the challenge of performance appraisal system which are composed of problems, limiting and challenge of performance appraisal system. Superiors, as evaluators, are usually required to rate the performance of many employees. Contrast error occurs when the manager compares an employee's performance to other employees instead of the company standard. When employees are ranked in comparison, someone must end up at the bottom, even if they are exceeding the company standard. The problem is not

the employee. It is the goal or standard that has been set. Moreover, there is an order effect, i.e. individuals who are rated first are rated higher than those evaluated last. If the time gap between the two evaluations is large, the effect is larger. This issue is of great importance in evaluations aimed at electing or employing individuals.

Obviously, no method can claim that it has an integrated approach in performance appraisal. Therefore, human resource managers should select an appraisal method which is most efficient in their organizations. A part of human resource management is performance appraisal to improve corporate performance. Developing clear, realistic performance standards can also reduce communication problems in performance appraisal feedback among managers, supervisors, and employees [5].

An effective PA program should do more than set salary and promotion decisions on past performance. It should aid in the development of a performance improvement plan that utilizes coaching from the department supervisor or manager to increase skills development. This puts it in the same category as training, which is all about looking ahead and developing practical program that result in improved performance [10, 11]. If the evaluator knows that a poor appraisal could significantly hurt the employees' future – particularly opportunities for promotion or a salary increase – the evaluator may be reluctant to give a realistic appraisal. There is evidence that it is more difficult to obtain accurate appraisals when important rewards depend on the results. The main objective of proposed integrated fuzzy model (IFM) for PA is to enhance the skill set of employees by comparing among the employees and determining the targets for improvement and that biases do not arise.

Employee performance indicates the result of work from employee in conducting the job based on competence, manner, and motivation. In evaluating employee performance, there are many factors, including loyalty, responsibility, discipline, integrity, teamwork, and leadership factors. Employee roles in advancing the organization is needed because without a good performance, the organization cannot achieve its objectives well. Most people think about the employee performance evaluation is done subjectively from the result of meeting; hence, the result of evaluation is not accurate. Based on the ANFIS research model on employee performance [12], The conclusion from employee performance evaluation model has a good level of accuracy compared with back propagation algorithm. The ANFIS model is considered the best if it produces the smallest RSME error rate.

Machine learning algorithm are used in various fields but unfortunately, the probability of overfitting of a learning algorithm which increases with

the number of features Therefore, feature selection techniques are powerful tools to avoid overfitting by decreasing the dimensionality of a data. Feature selection methods work by identifying a subset of "meaningful" features from a set of the original features. They can be subdivided into filter, wrapper and embedded methods. One of the common ways and is going to be used in this research is by using analysis of variance [13]. This paper aimed to show that the classification performance of a high-dimensional features data can be improved by applying feature selection method.

This article proposes an approach to minimizing subjective judgement in the effective employee evaluation in the existence of the multi-factor competency-based measures in a hierarchical structure using an adaptive neuro-fuzzy inference system (ANFIS) and analysis of variance (ANOVA) algorithm. Moreover, this study is to develop a more objective method for assigning right people with the corresponding talents to right positions, in human resource management system. Provided new point of view and convenience to the HR managers. The method suggested helps HR managers to make more objective decisions. Especially the predicting behavioural competencies of employees to make investment in human development more effective It is also a change in the decision-making concept of human resource development (HRD) from feelings to decision based on more information.

The rest of the paper is organized into four sections; Related works, Materials and Methods, Results and Discussions. In the first section the current studies on the themes of performance appraisal practice. Its correlation to HRD and decision support system are highlighted. The second section, Materials and Methods, gives an overview of methodological process as well as the study's objectives. In the third section, the results are presented comparison graph between performance of the MSE, MAPE, MAE, and RMSE for three models. The last section, Discussion and Conclusions, connects results with theoretical framework and addresses how it works in terms of HRD.

2 Related Works

2.1 Performance Appraisal

Performance appraisal is one of the most widely researched topics in all of personnel psychology. In recent years attention has been even greater because of important potential implications relating to fair employment practices and because of increasing concerns about employee productivity in organizations. Much of this rather voluminous literature on appraisals has focused on

Table 1 The summary of 360-degree performance appraisal methods with pros and cons

Key Concept	Pros	Cons
Allows employees to gain a more understanding of their impact on people they interact with every day.	More complete assessment Create better teamwork See how about the others though More feedback is always better	It can create a negative culture It might not be accurate Too focused on weakness

improving the accuracy of ratings by means of better instrumentation and more effective rater training. However, the present study is concerned with the effects of received appraisals on those being evaluated [14].

Employee PA became a widely used human resource management (HRM) tool in business around 1980's to measure the frameworks set by organizations regarding their employees [15]. In general, the PA is concerned with three possible measures, namely, assessing results, behaviours and personal characteristics. Each dictates a specific type of appraisal format based on competency or job-related behavior. 360-degree evaluations are the approach to evaluating performance. It is a popular performance appraisal method that involves evaluation input from multiple levels within the firm as well as external sources [5]. A 360-degree appraisal has four integral components: (1) self-appraisal, (2) superior's appraisal, (3) subordinate's appraisal and (4) peer appraisal.

As shown in Table 1 each method has pros and cons. In order to determine the 360-degree appraisal method. His study, however, was limited in its application as he proposed that difficult to interpret the findings when they differ from group to group. It may have more illustrative to use a quantitative technique for ranking decision alternatives using multiple criteria [16]. Structuring the alternatives into a hierarchical framework fuzzy related appraisal technique to resolve complicated decisions.

PA is intended to engage, align and coalesce individual and group effort to continually improve overall organizational mission accomplishment [17]. Several have agreed that well-designed and properly used appraisal systems are essential for effective functioning of organizations. With a view to eliminate these shortcomings, an attempt has been made with an integrated fuzzy multi-attribute decision making (FMADM) model to appraise and aid to improve their skills. The face of traditional human resource (HR) services in progressive organizations is currently undergoing a dramatic change [18].

An effective PA program should do more than set salary and promotion decisions on past performance. It should aid in the development of a

performance improvement plan that utilizes coaching from the department supervisor or manager to increase skills development. This puts it in the same category as training, which is all about looking ahead and developing practical program that result in improved performance [11].

2.2 Fuzzy Logic

Decision making can be based on decision makers imprecise perception relying on his/her subjective ideas, experience and beliefs [19]. This situation can be considered also for human resource selection as a decision-making process. It is common sense that personnel selectors tend to include as many elements as possible in their decision-making process, without being able to clearly define which element has the greatest impact on the outcome of a decision [20]. Decision made under these circumstances is defined as subjective judgment [21]. In complex decision-making problems involving ambiguous cases, human-perception and decision-like processes are inevitably to be utilized. According to Zhang, Huang, Ngai, and Chen (2010) one of the disadvantages of using conventional approaches for describing vague system is that the parameters obtained may not be easily to be interpreted by human beings. These are realized by artificial intelligence techniques (such as neural networks and fuzzy logic), Analytic Hierarchy Process (AHP) etc. Fuzzy Logic is an artificial intelligence (AI) technique. AI comes with the purpose of developing models and programs of the intelligent behavior. One of the approaches of the AI is Logic, with the main objective of formalization of natural reasoning. Fuzzy logic has two main components: membership functions and fuzzy rules. Using them it is possible to move a qualitative to a quantitative description, for example, to represent linguistic expressions as mathematic expressions. This is very useful when it is necessary to model the expertise of a human expert. Fuzzy membership functions express the certainty than an element of the universe belongs to a fuzzy set. It represents the degree of truth as an extension of the valuation. Degrees of truth are very often confused with probabilities, but they are conceptually different because fuzzy truth represents [22].

In term of research studies have been published on the connections between competencies and fuzzy logic, as the notion of competency is close to the approaches of fuzzy logic. Grabot and Tchuente [23] studied competency assessment for implementation of individual process activities and alerted to the shortcomings of the most frequently used numeric assessment. The focus was on competency management in terms of knowledge, skills and

abilities. They theoretically presented a possible formation of membership functions for several competencies and assessment analysis process. They noted that the use of fuzzy logic in competency assessment is a great example of the method's use and that with the use of fuzzy logic more credible results are expected when assessing the differences between the required and expected competencies than with usual assessment methods [24].

Lasserre, A.A., Solabac, M.V., Hernandez-Torres, R., Posada-Gómez, R., Juárez-Martínez, U., & Lambert used fuzzy logic for Expert System for Competences Evaluation 360° Feedback Using Fuzzy Logic. System testing in a production company in Mexico confirmed the advantages of using fuzzy logic in this field. Fuzzy Logic is a very good tool for decision problems, especially when non precise or partially precise description is available [22].

HR managers and field experts of the particular job field which check for the particular skills of individuals to select or score them by collective decision of group. This contains high uncertainty when it needs to be automated. The concepts of soft computation like Fuzzy Logic helps to deal with that kind of uncertainty and Neural network could be used to assign weights and then score the employee performance to rank them. The neuro-fuzzy based system uses hybrid network which combines the principles of neural networks and fuzzy logic. A fuzzy logic is multi-layer neural network of special structures without feedback that uses weighed method and activation functions. The main aim of this system is to take sample data set as input which will help them in determining parameters required for membership function [25].

Using such hybrid system application would highly benefit the organization to choose a quality employee based on his/her characteristics. It only requires requirements to be specified to the system which in turn would automate the ranking [26].

These are potent, efficient and flexible methods worked out in the literature extensively. They have found numerous applications in industry. One of the remarkable application areas is the employee selection which is a function of HRM department. This turns out to be a talent management problem, starting from the recruitment through the development and the rewarding of the personnel [27]. Therefore, talent management (TM) concept is introduced in order to deal with the gap and reveal the required personnel profile. TM raises institutional awareness and is a supportive tool for HRM. The TM contributes to remove wastes of the companies and supports self-improvement of its employees. In other words, the TM is a key of success about exploring abilities.

In addition to decision-making issues, the enhancement in technology and cultural shifts are causing huge changes in the organization standard. The HR professional plays vital role in assorting expert workforce of organization. The HR department examine their recruitment tools for software and employee management strategies. HR recruiters spend huge amount of time in inputting candidate's information into systems and speaking with managers about the specific requirements of certain position. HR professionals also faces problem of competencies scoring from candidates with strong backgrounds or skill set needed for the position. One of the main goals of the organization is finding more powerful ways of assessing and recruiting talent to manage the training budget. To strike a great balance between hiring someone for position need versus hiring someone that's great regardless of position there is need to automate the procedure of personal assortment of the candidate.

2.3 Artificial Intelligence (AI) and HR

In developing the automated system, Artificial Intelligence (AI) is rapidly applied nowadays. The appropriate selection of the classifier to be implemented is one of the most important tasks in any decision-making system [28]. During the last 20 years, Artificial Neural Network (ANN) is one of the many artificial intelligence types that proved to have a great impact on the interpretation of human resource management data. Machine learning algorithm such as ANN are used in various fields but unfortunately, the probability of overfitting of a learning algorithm which increases with the number of features [29]. Therefore, feature selection techniques are powerful tools to avoid overfitting by decreasing the dimensionality of a data. Feature selection methods work by identifying a subset of "meaningful" features from a set of the original features. They can be subdivided into filter, wrapper and also embedded methods. Among all this various type of feature selection, we utilized the filter methods as it thus not depends on any specific classification method and thus very suitable to be used in any classification method that favor [30]. From the study obtained, it can be concluded that ANN with feature that undergo feature selection method produce a better classification accuracy compared to the ANN with feature that did not undergo feature selection method. Therefore, can be conclude that feature selection is a process that is crucial to be done in order to produce a good performance rate [13].

In this study, a fuzzy logic approach is proposed in order to deal with uncertainty and vagueness in assessment of talent management by applying

feature selection concept. The purpose of this study is to develop a more objective method for assigning right people with the corresponding talents to right positions, in human resource management system. Provided new point of view and convenience to the HR managers. The method suggested helps HR managers to make more objective decisions. Especially the predicting behavioural competencies of employees to make investment in human development more effective It is also a change in the decision-making concept of human resource development (HRD) from feelings to decision based on more information.

The remaining part of this paper is organized as follows: Section 2 presents the proposed system architecture as well as its operational principle. Section 3 presents experimental results and discussion, while, Section 4 presents the conclusion of the study.

3 Materials and Proposed Methods

In this section is organized into 2 parts; data input variables definition and variables description categories, proposed model for human resource performance appraisal and data analysis process of this study. In the first part the data collection and data set used in the experiment in the present study and variables description. The second part, The overall of proposed model for human resource performance appraisal and data analysis process.

3.1 Proposed Model

Neuro-fuzzy modelling refers to the way of applying various learning techniques developed in the neural network literature to fuzzy modelling or a fuzzy inference system (FIS) [31]. Neuro-fuzzy system, which combine neural networks and fuzzy logic have recently gained a lot of interest in research and application. The neuro-fuzzy approach added the advantage of reduced training time not only due to its smaller dimensions but also because the network can be initialized with parameters relating to the problem domain [32] Such results emphasize the benefits of the fusion of fuzzy and neural network technologies as it facilitates an accurate initialization of the network in terms of the parameters of the fuzzy reasoning system. A specific approach in neuro-fuzzy development is the adaptive neuro-fuzzy inference system (ANFIS), which has shown significant results in modelling nonlinear functions [33].

Optimizing the values of the adaptive parameters is of vital importance for the performance of the adaptive system. Jang et al. Karim [31]

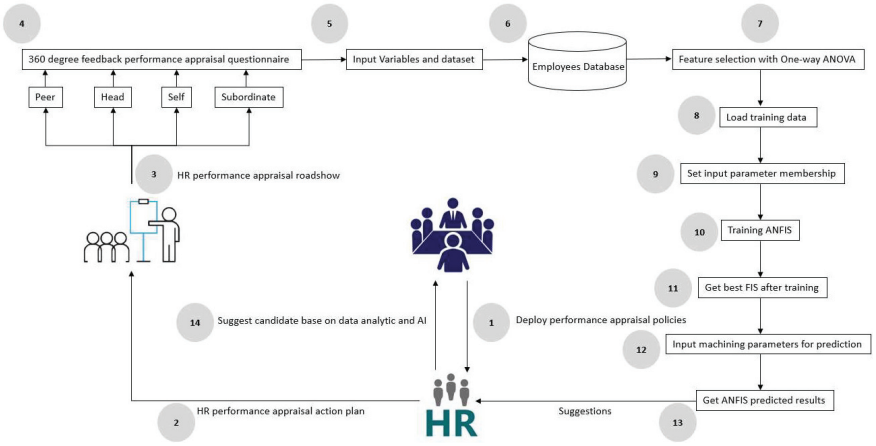

Figure 2 Proposed model for human resource performance appraisal.

developed a hybrid learning algorithm for ANFIS which is faster than the classical backpropagation method to approximate the precise value of the model parameters. Researcher observe that, given fixed values of elements of premise parameters, the overall output can be expressed as a linear combination of the consequent parameters.

The framework that drives the proposed performance appraisal model is presented in Figure 2. The architecture consists of three sequential stages namely the data processing, feature selection processing and ANFIS stages.

The paper proposed as shown in Figure 2 have a step as follows;

- Top management deploy corporate strategy and performance appraisal policies to HR department
- HR team make an action plan align with corporate strategy and HR policies
- Communicate to all department to improve understanding in corporate
- Rating on 360-degree feedback questionnaires
- Input the data by format
- Centralize employee performance into HR database for data cleaning preparation
- Filter data input with feature selection process
- Separate the data and loading training data
- Setup input parameter then training the function
- Got best fuzzy function after training
- Input machine parameter

Table 2 Input variables definition and their value rating

Code	Input Variable Description
CO	Communications
S	Self-motivation
I	Interpersonal skills
D	Decision making
K	Knowledge/Skill
CA	Career development
M	Management

Table 3 Variables description categories

Numeric Rating	Linguistics Categories
1	Strongly Disagree
2	Disagree
3	Neither Agree nor Disagree
4	Agree
5	Strongly Agree

- Provided suggestion to HR department
- Report to high level management and get feedback

3.1.1 Data collection

The data set used in the experiment in the present study is compiled from the database management system, based on the results of the behavioural competency assessment of petrochemical businesses in Thailand. The questionnaire is designed according to the 360-degree performance assessment question, considering performance, values or existing behavioural frameworks. Which are presented in Table 2.

The total of structured questions that relate to the operational procedure of the organization were coined and the response of an employee to each of the question was quantified with a Likert scale that range from 1 (Strongly Disagree) to 5 (Strongly Agree) as shown in Table 3.

The questionnaires were distributed by the human resource officers of the organization to the employees to obtain a set of relevant information that could aid decision making with respect to staff appraisal. To obtain objective response from the employees, the staffs were not in any way informed that the questionnaires would be considered in appraising their performance. Then, the required data were extracted from the feedback of

the questionnaires, and subsequently used to evaluate the built Fuzzy based appraisal model. The yearly data of year 2016 to 2017 is used by the model, so a total of records is accessed, out of which 90 percentage of records are used by the training data and 10 percentage of records are used by test data. Steps of applying the model on data analysis process as shown in Figure 3.

Start the research process by extracting data from excel file "Input variables.xlsx", which specifies that column will be a class of training process, which will be all the data from 2016 to 2017 combined into one file. The process of dividing the data into k-fold is known data sets (90% for training) and unknown data (10% for testing) and then assigning a quarter to the data. Preparing the data to convert the class that is the department name into numbers for using FIS logic. Import data into ANOVA to select the group relationships of the group "boss", "co-worker", "self" and "subordinate" to get the best relationship. This will result in better predictions with ANFIS when the correlation data is obtained. The ANOVA method and will continue to use that type of data in ANFIS.

In the next steps, using the "anova1" function, then the system returns the relation. The calculated data in a loop to complete, we will get the total probability based on the permutation. Calculate minimum position to retrieve the data. We will get the best relationship data and send it to ANFIS to continue working. Multiply the weight of the input and normalization data using the minimum to maximum method. Prepare to send the data we divide from "90/10" into the "FIS" process. The FIS will use the method of creating a member function "genfis3", which is clustering the data to use the range to assign values to the "gauss mf graph".

The clustering process will automatically find the range of graphs that should be based on the values with function "genfis3" in MATLAB. The "genfis3" generates an FIS using fuzzy c-means (FCM) clustering by extracting a set of rules that models the data behavior. The function requires separate sets of input and output data as input arguments. We use genfis3 to generate an FIS structure of the specified "sugeno" type. The FIS that we created is put into the structure of ANFIS. We specify the parameters of "ANFIS" such as "MaxEpoch", "ErrorGoal", etc. We will use Backpropagation training methods for the "ANFIS function". "The ANFIS" structure as shown in Figure 3.

Sugeno is a form of fuzzy inference that the consequence of each rule consequent is a constant or linear combination of the inputs. The output variables are gained by using fuzzy rules to the fuzzy input sets. In order

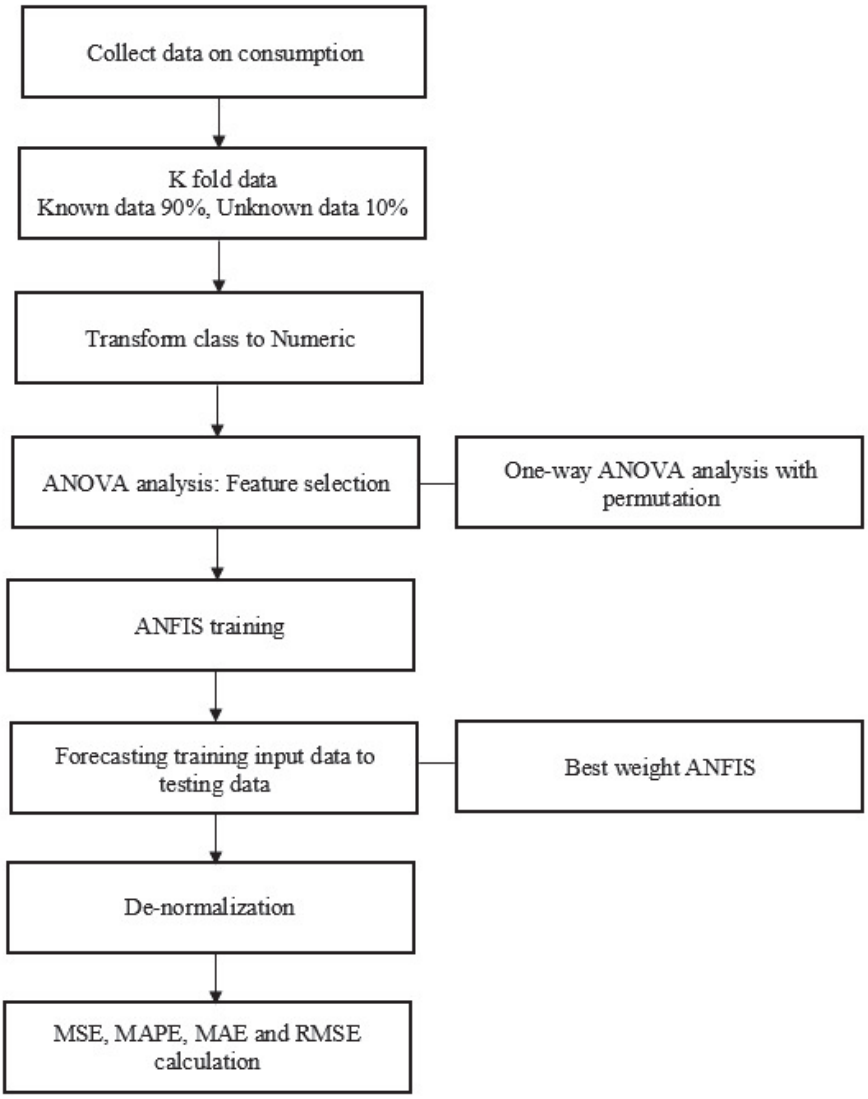

Figure 3 Proposed data analysis process to support human resource performance appraisal.

to calculate the output, the weighted linear mixture of the consequent is computed. The first layer is the input layer. the input layer consists of two inputs, x and y, however, in actual modelling, the input layer embraces four factors, namely: CO, S, I, D, K, C and M.

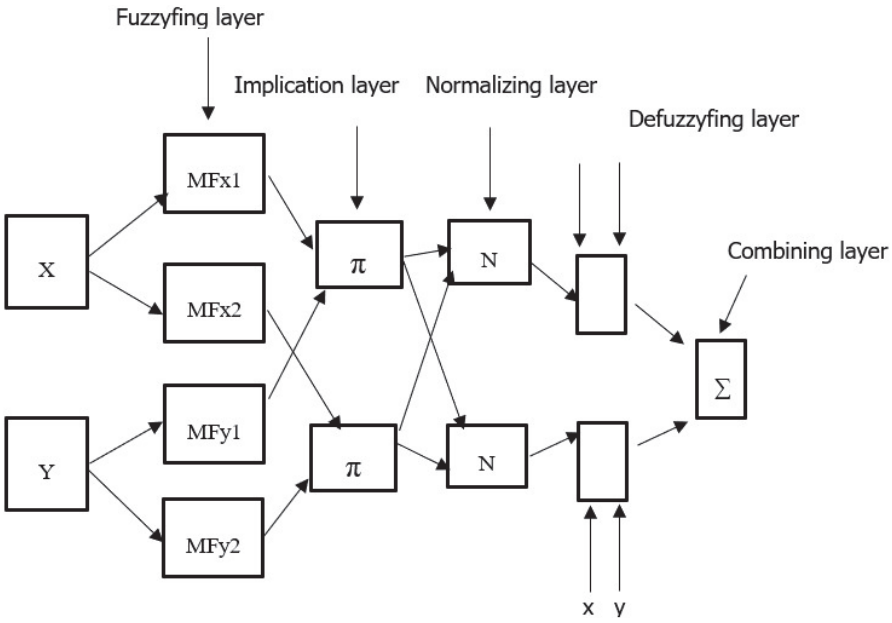

Figure 4 Schematic ANFIS structure for two inputs and two rules.

The output variables are gained by using fuzzy rules to the fuzzy input sets. Since it is supposed to use ANFIS, only zero-order or first-order Sugeno fuzzy inference system can be applied. The samples of zero-order and first-order rules are as follows;

Zero – order: If x is (MFx1) and y is (MFy1), then $f_1 = c$
First – order: if x is (MFx2) and y is (MFy2),
Then $f_2 = a_1x + b_1y + c_1$

In order to calculate the output, the weighted linear mixture of the consequent is computed. A schematic combining the first-order Sugeno model with two inputs and two rules.

The "FIS" that we created is in layers 2 and 3 which are shown in the section fuzzification layer and rule layer when entering the process backpropagation (Continue forward and backward according to the number of training cycles). The system will calculate the output to get the appropriate value, if still going back to adjust the rule (which is to adjust the range of the new mf) and then feedforward again to complete the training cycle until the best weight comes out. In which the rules as shown in Figure 5.

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'1. If (in1 is in1cluster1) and (in2 is in2cluster1) and (in3 is in3cluster1) and (in4 is in4cluster1) and (in5 is in5cluster1) and (in6 is in6cluster1) and (in7 is in7cluster1) and (in8 is i
'2. If (in1 is in1cluster2) and (in2 is in2cluster2) and (in3 is in3cluster2) and (in4 is in4cluster2) and (in5 is in5cluster2) and (in6 is in6cluster2) and (in7 is in7cluster2) and (in8 is i
'3. If (in1 is in1cluster3) and (in2 is in2cluster3) and (in3 is in3cluster3) and (in4 is in4cluster3) and (in5 is in5cluster3) and (in6 is in6cluster3) and (in7 is in7cluster3) and (in8 is i
'4. If (in1 is in1cluster4) and (in2 is in2cluster4) and (in3 is in3cluster4) and (in4 is in4cluster4) and (in5 is in5cluster4) and (in6 is in6cluster4) and (in7 is in7cluster4) and (in8 is i
'5. If (in1 is in1cluster5) and (in2 is in2cluster5) and (in3 is in3cluster5) and (in4 is in4cluster5) and (in5 is in5cluster5) and (in6 is in6cluster5) and (in7 is in7cluster5) and (in8 is i
'6. If (in1 is in1cluster6) and (in2 is in2cluster6) and (in3 is in3cluster6) and (in4 is in4cluster6) and (in5 is in5cluster6) and (in6 is in6cluster6) and (in7 is in7cluster6) and (in8 is i
'7. If (in1 is in1cluster7) and (in2 is in2cluster7) and (in3 is in3cluster7) and (in4 is in4cluster7) and (in5 is in5cluster7) and (in6 is in6cluster7) and (in7 is in7cluster7) and (in8 is i
'8. If (in1 is in1cluster8) and (in2 is in2cluster8) and (in3 is in3cluster8) and (in4 is in4cluster8) and (in5 is in5cluster8) and (in6 is in6cluster8) and (in7 is in7cluster8) and (in8 is i
'9. If (in1 is in1cluster9) and (in2 is in2cluster9) and (in3 is in3cluster9) and (in4 is in4cluster9) and (in5 is in5cluster9) and (in6 is in6cluster9) and (in7 is in7cluster9) and (in8 is i
'10. If (in1 is in1cluster10) and (in2 is in2cluster10) and (in3 is in3cluster10) and (in4 is in4cluster10) and (in5 is in5cluster10) and (in6 is in6cluster10) and (in7 is in7cluster10) and
'11. If (in1 is in1cluster11) and (in2 is in2cluster11) and (in3 is in3cluster11) and (in4 is in4cluster11) and (in5 is in5cluster11) and (in6 is in6cluster11) and (in7 is in7cluster11) and
'12. If (in1 is in1cluster12) and (in2 is in2cluster12) and (in3 is in3cluster12) and (in4 is in4cluster12) and (in5 is in5cluster12) and (in6 is in6cluster12) and (in7 is in7cluster12) and
'13. If (in1 is in1cluster13) and (in2 is in2cluster13) and (in3 is in3cluster13) and (in4 is in4cluster13) and (in5 is in5cluster13) and (in6 is in6cluster13) and (in7 is in7cluster13) and
'14. If (in1 is in1cluster14) and (in2 is in2cluster14) and (in3 is in3cluster14) and (in4 is in4cluster14) and (in5 is in5cluster14) and (in6 is in6cluster14) and (in7 is in7cluster14) and
'15. If (in1 is in1cluster15) and (in2 is in2cluster15) and (in3 is in3cluster15) and (in4 is in4cluster15) and (in5 is in5cluster15) and (in6 is in6cluster15) and (in7 is in7cluster15) and
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Figure 5 The training cycle to create the best weight calculation.

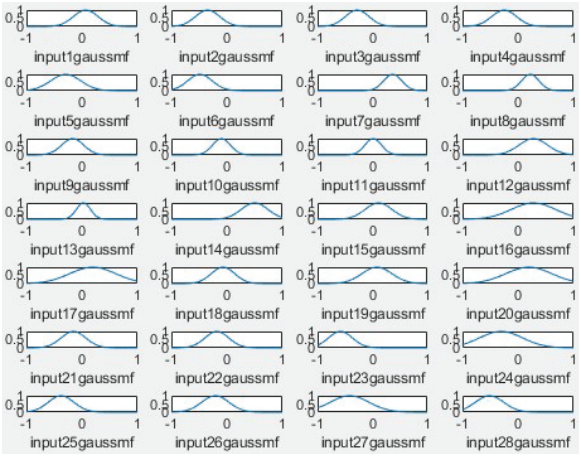

Figure 6 Employee performance prediction interface of the proposed system.

The "mf function" will calculate this format in each round both of these will be continuously adjusted for the training of backpropagation. Testing ANFIS by inputting 10% of unknown data from the test to get the value and then reverse to normalize the value. As shown in Figure 6.

The prediction errors are calculated using all mentioned performance measures i.e., MSE, MAPE, MAE and RMSE for fuzzy, neuro-fuzzy and neuro-fuzzy models with feature selection method. The Table 4 shows a quick summary of the acronyms and their basic characteristics.

The final step is to calculate the various errors related to each graph and display the results of both 2D graphs MSE, RMSE, MAP, MAPE. As shown in the next section.

Table 4 Forecasting performance comparison by MSE, MAPE, MAE and RMSE

Acronym	Full Name	Residual Operation	Formulation
MAE	Mean Absolute Error	Absolute Value	$\mathrm{MAE} = \underbrace{\frac{1}{n}}_{\text{test set}} \sum_{i=1}^{n} \underbrace{\lvert y_i}_{\text{predicted vaue}} - \underbrace{\hat{y}_i \rvert}_{\text{actual value}}$
MSE	Mean Squared Error	Square	$\mathrm{MSE} = \underbrace{\frac{1}{n}}_{\text{test set}} \sum_{i=1}^{n} \underbrace{(y_i}_{\text{predicted vaue}} - \underbrace{\hat{y}_i)^2}_{\text{actual value}}$
RMSE	Root Mean Squared Error	Square	$RMSE = \sqrt{\frac{\sum_{i=1}^{N} (Predicted_i - Actual_i)^2}{N}}$
MAPE	Mean Absolute Percentage Error	Absolute Value	$MAPE = \overbrace{\frac{\boxed{100\%}}{n}}^{\text{Multiplying by 100\% converts to percentage}} \Sigma \left\lvert \frac{\overbrace{y - \hat{y}}^{\text{The residual}}}{\underbrace{\boxed{y}}_{\text{Each residual is scaled against the actual value}}} \right\rvert$

4 Experimental Results and Discussions

After fitting a time series model, one can evaluate it with forecast fit measures. When more than one forecasting technique seems reasonable for a particular application, then the forecast accuracy measures can also be used to discriminate between competing models. One can subtract the forecast value from the observed value of the data at that time point and obtain a measure of error. To evaluate the amount of this forecast error, the researcher may employ the mean error or the mean absolute error. The mean absolute error (MAE) or mean absolute deviation (MAD) is calculated by taking the absolute value of the difference between the estimated forecast and the actual value at the same time so that the negative values do not cancel the positive values. The average of these absolute values is taken to obtain the mean absolute error. The mean squared error (MSE) measure the variability in forecast errors. Obviously, the variability in forecast errors must be small. MAE and MSE are all scale dependent measures of forecast accuracy, that is, their values are expressed in terms of the original units of measurement. The root means

square error (RMSE) measures the average magnitude of the error. In it, the difference between forecast and corresponding observed values are each squared and then averaged over the sample. Finally, the square root of the average is taken. Since the errors are squared before they are averaged, the RMSE gives a relatively high weight to large errors. This means the RMSE is most useful when large errors are particularly undesirable. The percentage error (MPE) is the proportion of error at a particular point of time in the series. The average percentage error in the entire series is a general measure of fit useful in comparing the fits of different models. This measure adds up all of the percentage errors at each time point and divides them by the number of time points [34].

Which Performance Measure Is Best?

Following observations are made from the performance measures:

- It is usually best to report the root mean squared error (RMSE) rather than mean squared error (MSE), because the RMSE is measured in the same units as the data, rather than in squared units, and is representative of the size of a ”typical” error.
- The mean absolute error (MAE) is also measured in the same units as the original data, and is usually similar in magnitude to, but slightly smaller than, the root mean squared error. The mathematically challenged usually find this an easier statistic to understand than the RMSE.
- The mean absolute percentage error (MAPE) is also often useful for purposes of reporting, because it is expressed in generic percentage terms which will make some kind of sense even to someone who has no idea what constitutes a ”big” error in terms of dollars spent or widgets sold. The MAPE can only be computed with respect to data that are guaranteed to be strictly positive.

The final step is to calculate the various errors related to each graph and display the results of both 2D graphs MSE, RMSE, MAP, MAPE. As shown in Figures 7–9.

As for the performance evaluation of the number of epochs in Figure 5 the ANFIS with ANOVA selection features achieved the highest accuracy compared to the ANFIS without ANOVA selection features and FIS logic. The overall results of the classifiers with and without the use of feature selection method are shown in Figure 10.

To sum up, the best MSE calculation is achieved by ANFIS with ANOVA selection features, while the best MAPE calculation is achieved by ANFIS

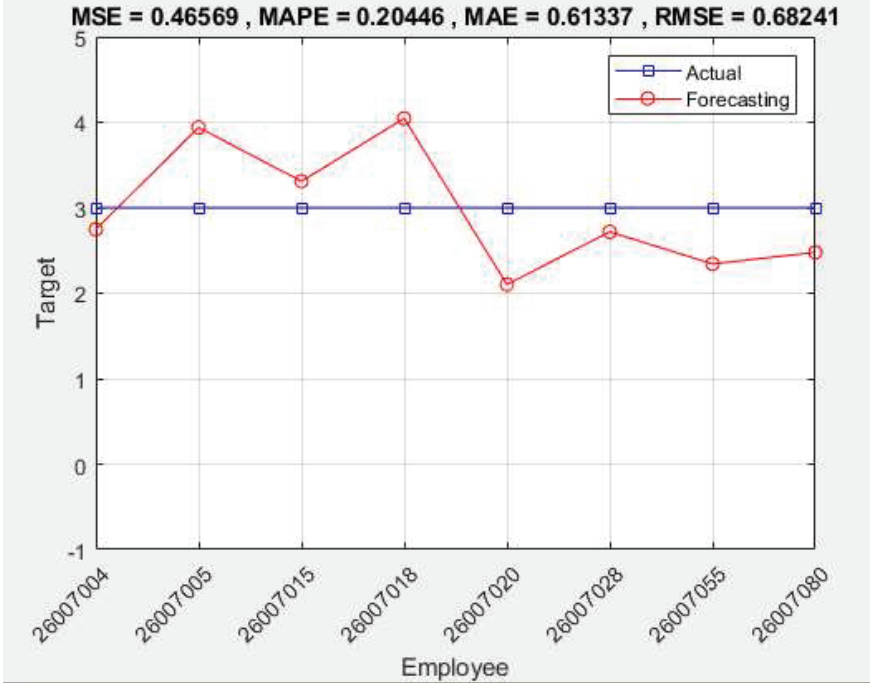

Figure 7 Graph showing comparison between actual employee competency scoring of 2018 with predicted employee competency scoring of 2018 using Fuzzy Predict.

Table 5 Forecasting performance comparison by MSE, MAPE, MAE and RMSE

Model	MSE	MAPE	MAE	RMSE
Fuzzy	0.4656	0.2044	0.6133	0.6824
ANFIS	0.0159	0.0348	0.1045	0.1261
ANFIS with ANOVA	0.0056	0.0185	0.0557	0.0751

with ANOVA selection features, while the best MAE calculation is achieved by ANFIS with ANOVA selection features, while the best RMSE calculation is achieved by ANFIS with ANOVA selection features. The overall results of the classifiers with and without the use of feature selection method are shown in Table 5.

Based on the results, the used of feature selection method produces a better result with a higher accuracy compared with the classifier that use data that not undergo the selection process, whilst, ANFIS with feature that undergo feature selection method produce a better classification accuracy.

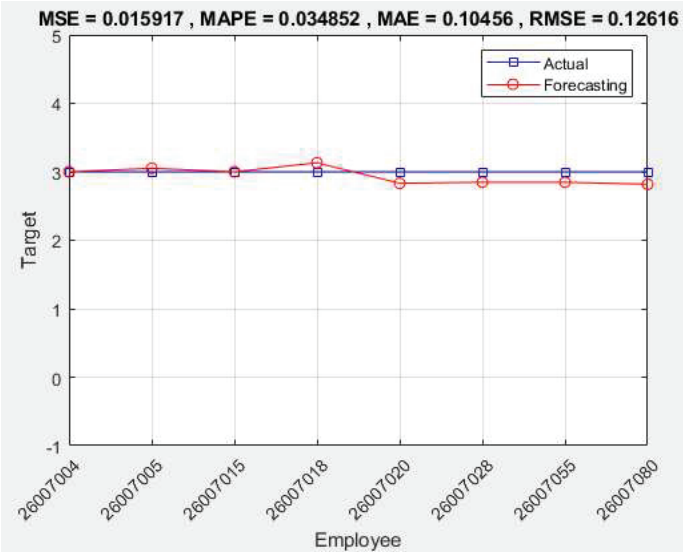

Figure 8 Graph showing comparison between actual employee competency scoring of 2018 with predicted employee competency scoring of 2018 using Neuro-Fuzzy Predict.

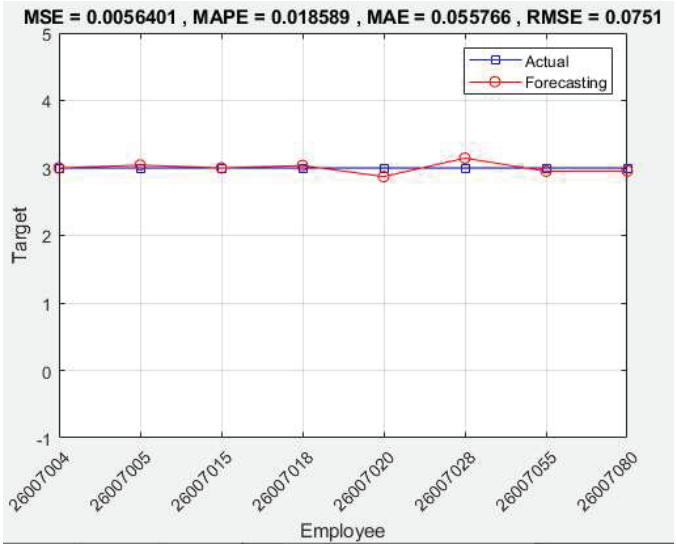

Figure 9 Graph showing comparison between actual employee competency scoring of 2018 with predicted employee competency scoring of 2018 using Neuro-Fuzzy Predict with feature selection method.

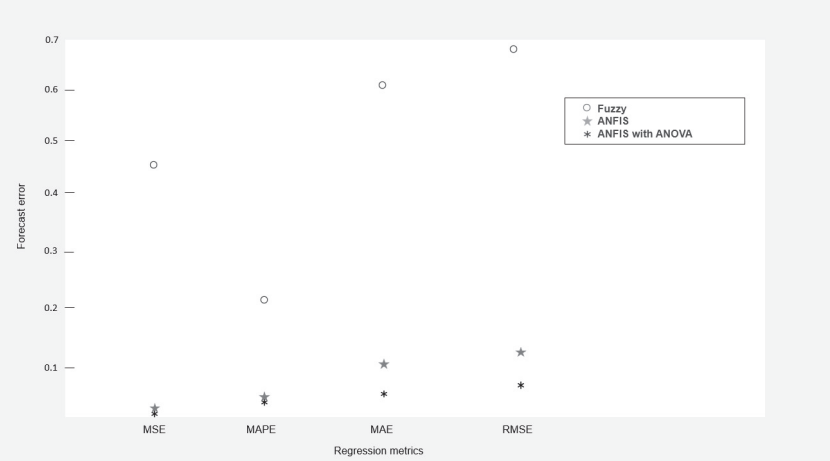

Figure 10 Graph showing comparison between performance of the MSE, MAPE, MAE, and RMSE for three models.

5 Conclusion

In this study, ANFIS models were developed to predict the performance appraisal with 360-degree feedback approach. The results of the study indicated that ANFIS methodology produced very successful findings and had the ability to predict competency scoring in 360-degree performance assessment. It was determined that the ANFIS model was a reliable method to predict competency score with an acceptable degree of accuracy and reduce human bias. Use of adaptive neuro-fuzzy inference system is significant for unclear system which has no experience with data behaviour. The outcomes of this research provide more information, simulation, and prediction about competency scoring in term of talent management. Therefore, ANFIS can be used in further researches on talent management strategy and employee development plan. Moreover, we show that the classification performance of a high-dimensional features data can be improved by applying feature selection method. One-way ANOVA were utilized and to evaluate the performance measure of the feature selection method, ANFIS was used. From the results obtained, it can be concluded that ANFIS performance using feature that undergo feature selection method produce a better classification accuracy compared to the ANFIS performance. Therefore, can be conclude that feature selection is a process that is crucial to be done in order to produce a good performance rate. AI is powered by what it calls its “not have human bias”.

This is a map of all the data connections within a performance assessment, not just in terms of data consolidation but align with corporate strategy and goals. AI is certain to have a dramatic effect on workforce management in the future. Enabling the drive digital transformation towards an ongoing, modern assessment culture is a positive step that is already being taken today. It's certain that it will raise concerns. They can certainly foresee headlines being made once people begin to feel they are being "fired by machines". These worries are justified, already many jobs are scheduled to be replaced by AI. But currently, the potential for positive change and a move away from unfair procedures towards ongoing, modern assessment, means this is likely to be an area of interesting new development.

References

[1] Armstrong, M. and A. Baron, *Performance management: the new realities. 1998*: London: Institute of Personnel and development.

[2] Lunenburg, F.C., *Performance Appraisal: Methods and Rating Errors*. International Journal of Scholarly Academic Intellectual Diversity, 2012. 14(1): p. 7–9.

[3] Gupta, C.B., *Human Resource Management*. 2000: Sultan Chand & Sons.

[4] Doran, G.T., *There's a S.M.A.R.T. way to write management's goals and objectives*. Management Review, 1981. 70: p. 35–36.

[5] Jafari, M., A. Bourouni, and R. Hesamamiri, *A new framework for selection of the best performance appraisal method*. European Journal of Social Sciences – Volume Number, 2009. 7.

[6] Tornow, W., *Perceptions or Reality: Is Multi-perspective Measurement a Means or an End?* Human Resource Management, 2006. 32: p. 221–229.

[7] Jones, J.E.a.B., W.L., *360° Feedback: Strategies, Tactics and Techniques for Developing Leaders*. 1996, HRD Press, Amherst, MA.

[8] Hoffman, *Ten reasons why you should be using 360-degree feedback*, in *HR Magazine*. 1995. p. 82–86.

[9] Shrestha, S. and J. Chalidabhongse, *Improving Employee Performance Appraisal Method through Web-Based Appraisal Support System: System Development from the Study on Thai Companies*. IEICE Transactions, 2007. 90-D: p. 1621–1629.

[10] Kirkpatrick, D.L., *Improving Employee Performance Through Appraisal and Coaching*. 2006: AMACOM, American Management Association.

[11] Gibson, S., R. Harvey, and M. Harris, *Holistic versus decomposed ratings of general dimensions of work activity*. Management Research News, 2007. 30: p. 724–734.
[12] Sulistyawan, R., et al., *Employee Performance Appraisal System Using Adaptive Neuro Fuzzy Inference System (Anfis): A Case Study of Amik Pakarti Luhur*. 2018.
[13] Shaharum, S.S., Kenneth & Helmy, Khaled, *Performance analysis of feature selection method using anova for automatic wheeze detection*. Teknologi, 2015.
[14] Pearce, J. and L. Porter, *Employee Responses to Formal Performance Appraisal Feedback*. Journal of Applied Psychology, 1986. 71: p. 211–218.
[15] Taylor, S., *People resourcing (3rd ed.)*. 2005: Chartered Institute of Personnel & Development.
[16] Russell, R. and B. Iii, *Operations Management/R.S. Russell, B.W. Taylor III*. 2020.
[17] Grubb, T., *Performance Appraisal Reappraised: It's Not All Positive*. Journal of Human Resource Education, 2007. 1: p. 1–22.
[18] Manoharan, T.R., C. Muralidharan, and S.G. Deshmukh, *An integrated fuzzy multi-attribute decision-making model for employees' performance appraisal*. International Journal of Human Resource Management – INT J HUM RESOUR MANAG, 2011. 22: p. 722–745.
[19] Saaty, T. and L. Vargas, *Decision making with the analytic network process. Economic, political, social and technological applications with benefits, opportunities, costs and risks*. Vol. 95. 2006.
[20] Petrovic-Lazarevic, S., *Personnel Selection Fuzzy Model*. International Transactions in Operational Research, 2002. 8: p. 89–105.
[21] Ayub, M., M. Kabir, and M.G.R. Alam, *Personnel selection method using Analytic network Process (ANP) and fuzzy concept*. 2009.
[22] Lasserre, A., et al., *Expert System for Competences Evaluation 360° Feedback Using Fuzzy Logic*. Inverse Problems in Engineering, 2014. 2014: p. 1–18.
[23] Hou, B. Grabot, and G. Tchuente, Fuzzy logic in competence management. 2011.
[24] Jevšček, M., *Competencies assessment using fuzzy logic*. Journal of Universal Excellence, 2016. 5: p. 187–202.
[25] Afshari, A. and D. Ćoćkalo, *Applications of Fuzzy Decision Making for Personnel Selection Problem – A Review*. Journal of Engineering Management and Competitiveness (JEMC), 2014. 4: p. 68–77.

[26] Amre, Y., M. Ahmedabadwala, and H. Damania, *Decision Making Approach in Recruitment using Neuro-Fuzzy System*. International Journal of Computer Applications, 2018. 180: p. 29–33.
[27] Karatop, B., C. Kubat, and O. Uygun, *Talent Management in Manufacturing System Using Fuzzy Logic Approach*. Computers & Industrial Engineering, 2014. 86.
[28] Sezgin, M.C., et al., *Classification of respiratory sounds by using an artificial neural network*. Vol. 17. 2001. 697–699 vol. 1.
[29] Grünauer, A. and M. Vincze, *Using Dimension Reduction to Improve the Classification of High-dimensional Data*. 2015.
[30] Mladenić, D., *Feature Selection for Dimensionality Reduction*. 2005. 84–102.
[31] Ismaeel, S. and K.M. Al-Jebory, *Adaptive Fuzzy System Modeling*. Journal of Engineering Technology, 2001. 20: p. 201–212.
[32] Xing, F., E. Cambria, and X. Zou, *Predicting evolving chaotic time series with fuzzy neural networks*. 2017. 3176–3183.
[33] Jang, J.-S., *Neuro-fuzzy and soft computing : a computational approach to learning and machine intelligence*. 1997.
[34] Mehrotra, D., *Performance Comparison of Time Series Data Using Predictive Data Mining Techniques Advances in Information Mining*. 2012. 4.

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