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An Adaptive Neuro-Fuzzy Inference System (ANFIS) Method for Recommending Employee Mutations in a Manufacturing Company

Achmad Solichin^{1*}, Fiqih Hana Saputri²

^{1,2} Faculty of Information Technology, Universitas Budi Luhur, Jakarta, Indonesia

*achmad.solichin@budiluhur.ac.id

Abstract. This research was conducted at Indonesia's leading rigid plastic and packaging company with a strong market position. At present, the company has expanded and opened branches in 6 countries in the Southeast Asia region. The problem occurred by the company is the opening of a new branch in Vietnam that requires several employees. The company issued a policy to select employees from companies located in Indonesia to meet the needs of employees in Vietnam. This study aims to facilitate the HRD in selecting employees who will be transferred. The total number of employees who meet the initial criteria for mutation are 666 employees. In this study, a recommendation system was developed that applies the Adaptive Neuro-Fuzzy Inference System (ANFIS) method. This method is a combination of Fuzzy Logic Method and Artificial Neural Network (ANN) Method. The criteria used in this study are employee attendance, duration of work of employees, employee psychology, employee job class, and employee performance. The results of this study indicate that ANFIS modeling with the hybrid algorithm along with the generated bell membership function can produce the best level of accuracy with an average Root Mean Square Error (RMSE) of 0.095561. We also developed a decision support system that applies the ANFIS method. Based on the quality testing of the DSS using the Software Quality Assurance (SQA), it obtained a quality value of 82.6%, which is in the range of good grades.

1. Introduction

This research was conducted at Indonesia's leading rigid plastic and packaging company with a strong market position. For simplicity, we call it XYZ. At present, the company has expanded and opened branches in 6 countries in the Southeast Asia region. The problem occurred by the company is the opening of a new branch in Vietnam that requires several employees. The company issued a policy to select employees from companies located in Indonesia to meet the needs of employees in Vietnam. With the growth of the company, these problems have the potential to occur continuously.

At present, the determination of employees to be transferred is done manually by the manager based on the employee's assessment sheet. The manual assessment is not objective. Also, the assessment is ineffective because it requires a long time to carry out a comprehensive analysis. Therefore a computerized system is needed in the process of appraising employees who can improve objectivity and speed up the assessment process. Based on interviews with related parties, there are five criteria used

for selecting employees. The five criteria are employee attendance, duration of work, employee characteristics, employee job class, and employee performance.

The selection of the best employees based on specific criteria has been made in several previous studies. Some popular methods include Adaptive Neuro-Fuzzy Inference System (ANFIS), Analytical Hierarchy Process (AHP), Simple Additive Weighting (SAW), Weighted-Product (WP), Multi-Factor Evaluation Process (MFEP), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Table 1 shows the various methods of decision support systems in the field of human resource development.

Table 1. Various methods of decision support systems in the field of human resource development

#	Method	Paper
1	Adaptive Neuro-Fuzzy Inference System (ANFIS)	[1–7]
2	Analytical Hierarchy Process (AHP)	[8–10]
3	Simple Additive Weighting (SAW)	[11,12]
4	Weighted-Product (WP)	[13]
5	Multi-Factor Evaluation Process (MFEP)	[14]
6	Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)	[15]
7	Profile Matching (PM)	[16]

Research by [8] proposed a decision support system on employee performance appraisal using the AHP model. The problem that was solved in the study was the lack of scientific technique for rating the employee's performances. The study uses five criteria: personal skills, initiatives, teaching quality, method of teaching, and research quality. The result obtained showed that the consistency ratio of the five criteria is 0.0976 which showed that there is consistency in all the criteria in appraising the performance of academic staff in Kampala International University (KIU) except research. In another study, the AHP method was also applied to the development of DSS in employee selection at CV. Asia Exotica [9]. The criteria used are education, work experience, age, and marital status. The test results show a match between DSS-based selection and manual selection. The AHP method also used by [10] for selecting the prospective employees.

Meanwhile, research by [14] uses the Multifactor Evaluation Process (MFEP) method to build a DSS for employee recruitment. The study selected new employees based on interview scores, psychological test scores, and computer skills scores. In the same case, employee recruitment, research by [13] developed a web-based DSS using the Weighted Product (WP) method. The criteria used are education, GPA, work experience, interviews, and skills tests. Another method, Simple Additive Weighting (SAW) is also used in the development of DSS to solve employee assessment problems at Narotama University [12].

In addition to the methods above, the methods that are widely used to develop DSS in the field of human resources is the Adaptive Neuro-Fuzzy Inference System (ANFIS) method [1,3,7]. Sulistyawan et al. [7] proposed the application of the ANFIS method to solve the problems of the AMIK Pakarti Luhur leader in conducting employee appraisal. Based on testing with the SQA method, it was concluded that the resulting DSS application was in good quality. Recent research by [1] also developed an automated evaluation model by combining the ANFIS method and Internet of things (IoT). The test in the study resulted in an accuracy of 94.7% and the RMSE value of 0.0717. ANFIS method is one of the best methods in developing DSS. The ANFIS method has several learning algorithm choices that can be adjusted to the problem [17].

Based on research problems and literature studies that have been carried out, in this study, a decision support system was developed to assist XYZ managers in evaluating and selecting employees who will be mutated to other branches. In this case, testing was carried out to select employees who would be transferred to a new branch in Vietnam. The method used in this study is ANFIS with assessment

criteria, including employee attendance, duration of work of employees, employee psychology, employee job class, and employee performance. The primary purpose of this research is to shorten the time in decision making and produce objective decisions. It is expected that with the system produced in this study, employees are satisfied with the results of company decisions in selecting the best employees who will be transferred to various branches of the company.

2. Methodology

In this section, the research framework, as presented in Figure 1, is explained. The whole framework comprises of four phases, namely, problem and solution design phase, criteria and data acquisition phase, ANFIS-based modeling phase, and finally DSS development phase. Each phase performs predefined tasks. The first phase is identifying problems and designing solutions based on literature studies from various previous studies. These stages have been explained in the introduction to this paper. The primary purpose of this research is to shorten the time in decision making and produce objective decisions, using the implementation of ANFIS-based DSS. Another phase will be explained below.

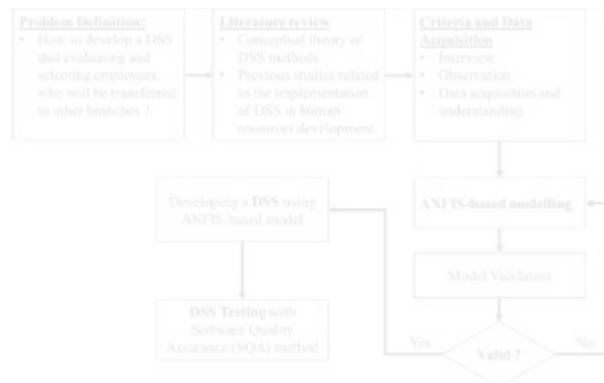


Figure 1. Research Framework

2.1. Criteria and Data Acquisition Phase

The stage of acquisition of data and criteria conducted by the method of interviews, observation, and questionnaires. The parties involved are the Director, General Manager, Plant Manager, and Personnel Manager. Based on interviews with related parties, obtained five criteria in the selection and determination of employees who will be transferred. The five criteria are attendance, duration of work, psychology, job class, and performance. The assessment of each criterion is carried out by the supervisor of the employee based on data, reports, or direct observations. First of all, the criteria for attendance and years of service are obtained based on data recorded in the data center. Next, for psychology criteria obtained through the psychotic test. Finally, the job class criteria and performance are obtained based on the direct evaluation of the supervisor. The employee value for each criterion is in the range of 56-100. The values obtained are converted into fuzzy sets, namely, poor, adequate, and excellent. The value range of 56-70 is in the poor category, 71-83 in the adequate category, and 84-100 in the excellent category.

In this study, the dataset was obtained from data of employees working between 2016-2018. This study took sample data as many as 250 employees from a total of 666 employees using Slovin

calculation method [18] with a degree of trust of 95%. Of the 250 employee data sampled, it is divided into two parts: 200 data as training, and 50 data as testing.

2.2. ANFIS-based Modeling Phase

ANFIS is an architecture that is functionally the same as Sugeno's fuzzy rule-based model [19]. ANFIS architecture is also the same as neural networks with radial functions with few specific restrictions [17]. The ANFIS method can adjust the rules adaptively using specific learning algorithms. In ANFIS, neural networks are used to implement the Fuzzy Inference System. The basic idea of the ANFIS function is straightforward, namely when given input data, the ANFIS function will change the shape of the "antecedent" and "consequent" functions such that the output from FIS will follow the output data. This method is adopted from training techniques from artificial neural networks (ANN).

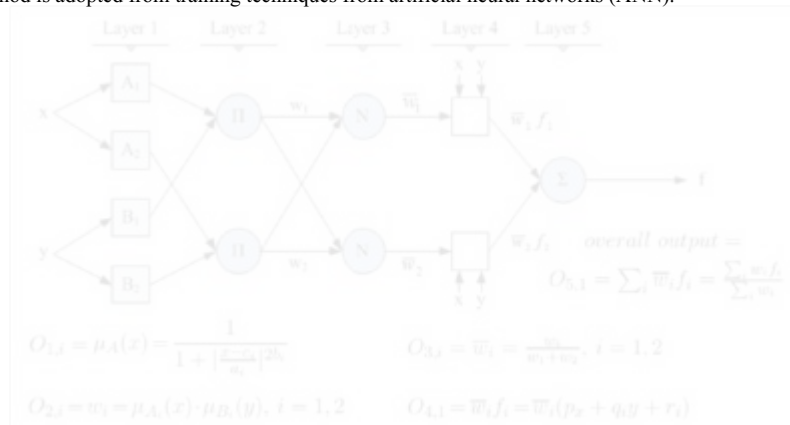


Figure 2. ANFIS-based learning model [2]

ANFIS-based modeling begins by initiating a model based on a dataset that is an input-output pair. Figure 2 shows the architecture with five layers and the corresponding mathematical formulations each of the layers [19,20]. Modeling also requires several membership functions and rules. Based on the membership function and pair of input-output data that is entered into the ANFIS system, a Fuzzy Inference System (FIS) is produced. ANFIS system can optimize membership functions (MFs) with hybrid and backpropagation algorithms. After ANFIS produces a model, the model must be tested for validation against the desired model criteria. The purpose of this process is to see how far the success of ANFIS is in modeling the system. ANFIS validates this model by comparing the output of the data that has been carried out by the learning process, with other data sets that were not carried out by the learning process. This comparison will produce an "error" called Root Mean Square Error (RMSE) and can be used as a measure of the success of the model. The smaller the RMSE, the better the model.

2.3. DSS Development Phase

ANFIS-based models that have been produced in the previous phase are applied to a decision support system. DSS development is carried out using Prototyping software development methods. The DSS application is developed using Matlab GUI. To find out the quality of the DSS produced, a series of tests were carried out. In this study, testing was carried out using the Software Quality Assurance (SQA) method. SQA is a model that is useful to analyze and understand the factors that influence the acceptance of the use of the software. A questionnaire was prepared as an instrument to assess the quality of the system produced. The aspects assessed in this study are auditability, accuracy, completeness, error tolerance, execution efficiency, operability, simplicity, and training. Each aspect of the assessment is

given a value weight (in the range 0-100%). After the application user gives an assessment, the overall value of software quality (Q) can be calculated by equation (1).

$$Q = \frac{\sum_{i=1}^n \sum_{j=1}^b C_{(i,j)} W_{(j)}}{n} \quad (1)$$

where n is the number of respondents, b is the number of aspects of the assessment, $C(i, j)$ is the value given by the respondent i for aspects of assessment j , and $W(j)$ is the weight for the aspect of the assessment j .

3. Result and Discussion

3.1. Testing of the ANFIS-based Model

The ANFIS-based model produced by the expectation is the best. Therefore, it is necessary to test to find the best algorithm for optimizing membership functions (MFs). In this study, two algorithms were tested, namely hybrid and backpropagation algorithms. As seen at Figure 3, the type of membership function (MF) that we tried are triangular (*trimf*), trapezoidal (*trapmf*), Gaussian (*gaussmf*), and generalized bell (*gbellmf*). We use the RMSE value as a measure of the performance of the resulting model. Table 2 presents a comparison of the RMSE value of the hybrid algorithm and backpropagation for each membership function applied to ANFIS-based models. Based on Table 2, it can be seen that the hybrid algorithm has a lower RMSE average (0.10264) than the backpropagation algorithm (0.13879). It shows that the hybrid algorithm is superior to be applied to ANFIS-based models. Meanwhile, it can be seen from the types of membership functions; the test results show that the *gbellmf* (generalized bell) function has the lowest RMSE value for both hybrid and backpropagation algorithms. Thus the type of MF used in this study is *gbellmf*.



Figure 3. Membership functions

Table 2. The comparison of the RMSE value of the ANFIS-based model

#	Membership Function (MF)	Algorithms	
		Hybrid	Backpropagation
1	Trimf	0.11213	0.15082
2	Trapmf	0.10283	0.13935
3	Gbellmf	0.09556	0.13149
4	Gaussmf	0.10005	0.13351
	Average	0.10264	0.13879

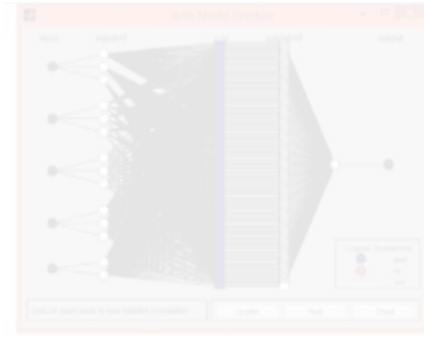


Figure 4. ANFIS model structure



Figure 5. The main view of the DSS application prototype

The ANFIS structure thus formed after training the system and adaptively generating FIS can be seen in Figure 4. It was showing us the relation between the input parameters, the input of membership function (MF), rules, and the output MFs took for decision (output) evaluation with their set range values. Figure 4 shows that the ANFIS model consists of 5 inputs, one output, and produces 162 rules. Furthermore, the resulting model is stored in the form of a *.fis file to be used at the DSS system development stage.

3.2. The DSS Development

The models and rules that were produced at the ANFIS-based decision support model stage were subsequently implemented in a DSS prototype. Figure 5 presents the main view of the DSS application prototype produced in this study. To generate recommendations, first of all, the user loads employee data via the "Alternative Load" button. Next, determine the threshold value, load the ANFIS model, and finally, press the "Rank the Alternative" button. The results of recommendations are displayed in table form and can be exported in the form of a Microsoft Excel file.

To measure the quality of the DSS application produced, the SQA method was used for testing. The aspects assessed in this testing are auditability, accuracy, completeness, error tolerance, execution efficiency, operability, simplicity, and training. Table 3 presents the aspects of assessment, and the weight of the assessment carried out in this study. A software quality assessment instrument with eight aspects of assessment, as seen in Table 3, is given to DSS application users. Users of applications fill out questionnaires in a closed and objective manner.

Table 3. Aspects of software quality assessment with SQA

#	Aspect	Description	Weight (%)
C1	auditability	The software meets the standard or not	10
C2	accuracy	How accurate data and information is provided	15
C3	completeness	Completeness of the application features	10
C4	error tolerance	The level of tolerance for errors in the application.	10
C5	execution efficiency	Efficiency in running applications	10
C6	operability	Ease of operating the application	15
C7	simplicity	Ease of understanding the application	15
C8	training	Ease in application implementation	15

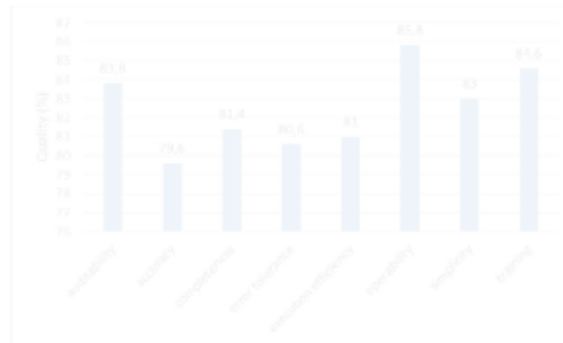


Figure 6. The DSS application quality assessment of each aspect

Based on the assessment given by all respondents to the quality of the DSS system produced in this study, then the total value of software quality is calculated by (1). The calculation results show the value of the DSS system quality of 82.6%. This value is included in the excellent category. Thus, the quality of the DSS system produced can be concluded that it meets the software quality standards. Meanwhile, Figure 6 presents the quality of the DSS system for each aspect of the assessment. Based on the graph, it can be interpreted that the operability aspect has the highest value (85.8%), which means the DSS system is easy to operate by the user. On the other hand, the accuracy aspect shows the lowest value compared to other aspects, namely 79.6%. It shows that the accuracy of the application in providing recommendations still needs to be improved.

4. Conclusion

Based on the discussion of the results of the research discussed in the previous chapter, some conclusions are obtained. First of all, the results of developing ANFIS-based DSS models using two different learning algorithms, namely hybrid and backpropagation algorithms, show that the application of hybrid algorithms and generated bell membership functions have advantages over another algorithm (triangular, trapezoidal, and Gaussian membership function). Next, the model in this study produced 162 rules as a knowledge base. The model has been successfully applied to the DSS application prototype to display employee recommendations that will be transferred. Finally, testing with the Software Quality Assurance (SQA) method on eight aspects of assessment resulted in an average value of 82.6%. This value is above the SQA test standard of 80% and falls into the category of excellent assessment.

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