IMPLEMENTATION OF ADAPTIVE NEURON FUZZY INFERENCE SYSTEM (ANFIS) ALGORITHM FOR PREDICTING PRICE OF GRAIN

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ABSTRACT

Grain is the result of rice plants that have been separated from the stems by threshing. At this time, many Indonesian farmers complain about the plummeting price of grain but the price of rice rises, that cause it to happen because traders are too big in taking profits and also the lack of farmer information in selling grain according to the criteria. In this study the grain price data based on quality consists of 2 ie water content and void levels obtained from BPS. ANFIS consists of two stages of advanced and backpropagation. During training the data will pass through the forward and backward stages to get the best RMSE value with updated parameters in each epoch, to get the smallest RMSE value or maximum epoch input. At the time of the test only advanced stage with parameter values taken from the value of training update parameters. Based on the results of the training using the data 7 months, 9 months and the last 11 months obtained RMSE value with the first epoch RMSEnya value as follows at 7 months by 20.11, at the time of 9 months of 120.342, and at the time of 11 months amounted to 132.392, so the value of RMSE the smallest comes at the time of data usage last 7 months.

Kata Kunci: Prediction, grain price, Neuro Fuzzy, ANFIS

1. INTRODUCTION

Grain is the result of rice plants that have been separated from the stem by threshing. Grain will later become rice and rice cooked and become rice, which is the staple food of Indonesian society. At present, many Indonesian farmers complain about the plummeting price of grain but the price of rice rises, which causes it to happen because the traders are too big in taking profits and also the lack of farmer information in selling grain according to the criteria. For that we need a system to predict the price of grain in determining the price of grain to be sold.

In the research on predicting the previous price of grain has been done by Reino Adi Septiawan by using Fuzzy Logic [1], but the output is not yet accurate yet because of the absence of error checking process and training on parameter data. So in this research will be used Adaptive Neuro Fuzzy Inference System (ANFIS) method in predicting the price of grain. ANFIS was once used in predicting gold prices by Antony and obtaining Mean Absolute Percentage Error (MAPE) of 0.38% [2], ANFIS was used also on the prediction of unemployment rate and earned RMSE of 1,274 [3] and also ANFIS was used to predict post value test students and get RMSE of 0.01 [4], from some of the above research can be seen that ANFIS method can produce small error value which means has a fairly high accuracy in predicting and also has the advantage of ANFIS learning techniques that can optimize the process so that can reduce processing time.

ANFIS method has advantages in learning techniques from artificial neural networks to optimize the process. Therefore, ANFIS method is expected to provide performance results based on output value with high accuracy and small error value in predicting the price of grain.

2. RESEARCH CONTENTS

2.1 Analysis

Adaptive Neuro Fuzzy Inference System (ANFIS) is an architecture that is functionally similar to Sugeno's fuzzy rule base model. The ANFIS architecture is also similar to neural networks with radial functions with few restrictions [5]. It can be said that ANFIS is a method which in doing the setting of rules used learning algorithm to a set of data. In ANFIS also allows the rules to adapt.

Analysis of the algorithm conducted in this study is to examine how ANFIS algorithm work in the prediction system of grain prices. In the ANFIS method there are several stages of analysis in the form of data processing layers, following

the steps in the ANFIS method is shown in Figure 1:

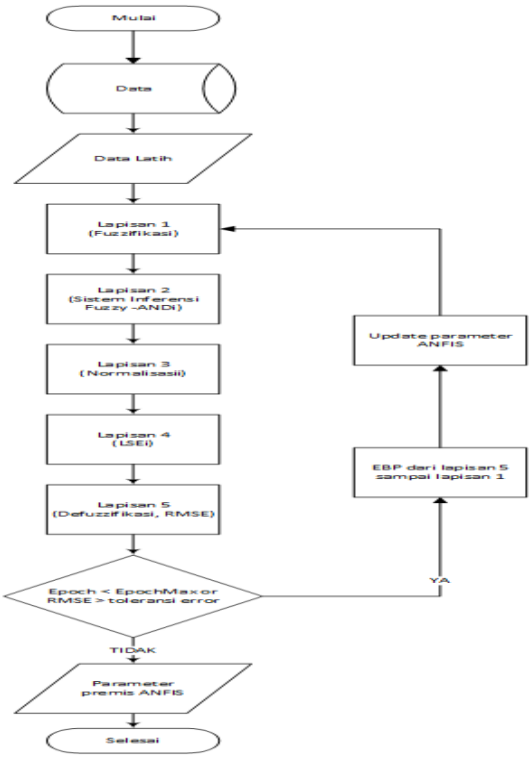


Figure 1 Flowchart ANFIS Method

Based on Figure 1 There are data input parameters that must be entered into the system as learning data that is data of water content and vacuum / dung. If the input data is correct, then proceed to the fuzzification process, in this process the input data is converted into a fuzzy membership function by changing the numbers that exist on a scale of 0 to 1. The next process is the inference engine, in this process reasoning on the input data for determination output value as a form of decision making. The last process is deffuzification, in this process a fuzzy set of mappings is mapped into a set of crips to generate output. After layer 1-5 is done, there is check whether epoch has fulfilled the desired epoch number and rmse has fulfilled the error tolerance limits, if both or one of them is true then the process will stop and will get new parameter value of training result that will be used at testing, if not yet fulfill one of the conditions then the ANFIS stage is repeated from the beginning with the values of a, b and c which can be from the previous epoch until one of the conditions is met.

ANFIS prediction process using several variables or data parameters that is moisture content and vacuum / dirt. Here is the architecture of ANFIS method that will be used in this research is shown in Figure 2:

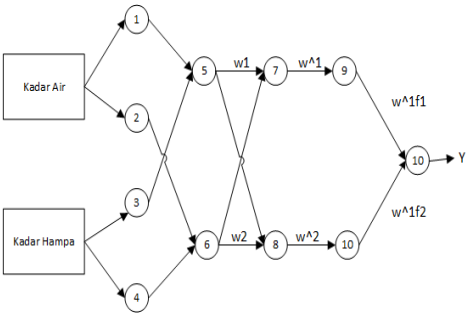


Figure 2 ANFIS Architecture

Looking at the ANFIS structure in Figure 3.3 it can be explained that each supporting parameter to predict the price of grain has two categories namely low and high in moisture content as well as vacuum to be processed in layer 1, then calculated weighting for each category on layer 2, then calculated average weight on layer 3, then calculate the learning value using LSE in layer 4 and calculate the final value in layer 5. which will produce the predicted price of grain.

The data to be used in this simulation is the last 7 months shown in table 1 as below:

Table 1 Illustration of Input and Output Table

WATER CONTENT	RESPECT OF HAMPA	TARGET OUTPUT
12.63	2.28	5457
12.87	2.14	5470
12.65	2.08	5502
12.71	2.18	5531
12.78	2.41	5593
12.24	2.17	5605
12.76	2.36	6089

1. Layer 1

In the first layer there is a fuzification process. This process is to map the input data into the fuzzy set. In this process we will calculate the fuzzy membership function to transform the classical set of entries to a certain degree. Membership function used is Generalized-Bell type.

$$gbell(x,a,b,c) = \frac{1}{1+\left|\frac{x-c}{a}\right|^{2b}}$$

The determination of categories seen from the levels of moisture content and void levels determined by the bulog in the determination of grain prices based on the quality is contained in

PERPRES no 5 of 2015 is GKG (Grain dry milled) with water content conditions smaller or equal 14% (<= 14 %) and the void content is smaller or equal to (<= 3%). Then the condition is divided into 2 categories ie if the moisture content is greater than 12.65% and smaller or equal to 14% (12.65% <KA <= 14%) and the void is greater than 2.25% and smaller or equal to 3% (2.25% <KH <= 3%) then it belongs to the high category and if the content is less than or equal to 12.5% (KA <= 12.65%) and the void content is smaller or equal to 2.25% (KH <= 2.25%) low category. Here are the input tables that have been categorized can be seen in table 2 below:

Table 2 inputs that have been categorized

Water Contents	Category	Respect of Hampa	Category
12.63	Low	2.28	High
12.87	High	2.14	Low
12.65	Low	2.08	Low
12.71	High	2.18	Low
12.78	High	2.41	High
12.24	Low	2.17	Low
12.76	High	2.36	High

Can be seen from table 3 obtained low water content category and also high then from the table got the value of a and c it. To illustrate the calculation can be seen below:

Max : 12.65
Min : 12.24
range = Max – Min
= 12.65 – 12.24 = 0.4137
a= range / 2
= 0.4137/ 2 = 0.205
c= a + Min
= 0.2069 + 12.24 = 12.45

The premise parameter will be initialized based on the input data in table 2 to be represented in the membership function curve. Based on the data in table 2 then the premise parameter to be used in the calculation of ANFIS method can be seen in table 3 below:

Table 3 Premise Parameters

		Water content	Respect of Hampa/Dirt
Low	**a**	0.207	0.05
	b	1	1
	c	12.44	2.13
High	**a**	0.08	0.065
	b	1	1
	c	12.79	2.34

After the determination of the premise parameter is completed then the next step is to calculate the membership function value of each parameter is the water content and the void content using equation [5]. From the above formula gbell then got the output for water content can dilihar at table 4:

Table 4 Layer 1 Output (Water Content)

Data to	Water Content (KA)	
	Low	High
1	0.551147541	0.2
2	0.188749158	0.5
3	0.5	0.246153846
4	0.374387528	0.5
5	0.272447326	0.984615385
6	0.5	0.020718679
7	0.297522124	0.876712329

For the output of vacuum layer / dirt can be seen in table 5.

Table 5 Layer 1 Output (Overlay)

Data to	Respect of Hampa (KH)	
	Low	High
1	0.1	0.5
2	0.961538462	0.091351351
3	0.5	0.056749496
4	0.5	0.134340223
5	0.030902349	0.5
6	0.609756098	0.121233859
7	0.045126354	0.949438202

2. Layer 2

The output of layer 2 is the multiplication of all incoming signals. Each node output states the degree of activation of the fuzzy rule. In layer 2 we will calculate the values of W1 and W2 of each membership value obtained from tables 3.4 and 3.5 by using the equation below [5].

$$O_{2.i} = w_i = \mu_{A_i}(x).\mu_{B_i}(y), untuk\ i = 1,2$$

The output of layer 2 can be seen in table 6 below:

Table 6 Layer Output 2

Data To-	W_1	W_2
1	0.055114754	0.1
2	0.181489575	0.045675676
3	0.25	0.013969107
4	0.187193764	0.067170111
5	0.008419262	0.492307692
6	0.304878049	0.002511805
7	0.013426089	0.832384177

3. Layer 3

Layer Each node in this layer is a non-adaptive node that displays the function of the normalized firing strength that is the output ratio of the i-th knot of the previous layer to the entire output of the previous layer, with the form of function [5]:

$$O_{3.i} = \bar{w}_i = \frac{w_i}{w_1 + w_2}, untuk\ i = 1, 2$$

From the above equation can be seen output layer 3 in table 7 below:

Table 7 Layer Output 3

Data To-	$\overline{W_1}$	$\overline{W_2}$
1	0.355316	0.644683999
2	0.798932	0.201068058
3	0.947081	0.052919476
4	0.735929	0.264070954
5	0.016814	0.983185922
6	0.991829	0.0081714
7	0.015874	0.984126359

4. Layer 4

In layer 4 is done the calculation of learning forward direction with RLSE (Recrusive Least Square Estimator) method that aims to find the value of A1..An to C1..Cn. After the value obtained then formed a matrix A.

$$A = \begin{bmatrix} 4.48764010 & 0.081012 & 0.355316 & 8.112358 & 1/469879 & 0.64468 \\ 3.33892192 & 0.602808 & 0.2643687 & 9.290819 & 1.677363 & 0.73563 \\ 8.59176235 & 1.428622 & 0.6675806 & 4.278237 & 0.711377 & 0.33241 \\ 11.733800 & 1.929352 & 0.9275731 & 0.916199 & 0.150647 & 0.07426 \\ 9.36783148 & 1.606756 & 0.73704417 & 3.342168 & 0.573243 & 0.26295 \\ 0.27777831 & 0.052383 & 0.0217357 & 12.50221 & 2.355761 & 0.97826 \\ 11.944515 & 2.119513 & 0.9761551 & 0.291772 & 0.051777 & 0.02384 \end{bmatrix}$$

From the above matrix A we will look for the consequent parameter value θ (teta) using Least-Squares Estimator (LSE) method. If the matrix A has a determinant value not equal to zero then the matrix is non singular, then the formula used [5]:

$$\Theta = (A^T . A)^{-1} . A^T . Y$$

And got the consequent result which can be seen in table 8 below:

Table 8 Consequent Parameters

Parameters	Θ
A1	-2177.146957
B1	-6361.3597
C1	46073.47452
A2	7082.485284
B2	-12872.56703
C2	-53853.64326

After the consequent values are obtained then the next step is to find the output layer 4, calculate the output layer 4dengan using equation [5]:

$$O_{4.i} = \bar{w}_i f_i = \bar{w}_i (p_i x + q_i y + r_i)$$

From the above equation we get the output of layer 4 can be seen in table 9 below:

Table 9 Output of the Fourth Layer

Data To-	$\overline{W_1} f_1$	$\overline{W_2} f_2$
1	1446.92078	4028.432425
2	3547.484261	1960.544035
3	5020.414511	474.4154895
4	3336.829277	2139.647735
5	49.07456994	5542.84054
6	5575.113407	40.0603386
7	52.06983601	6042.152796

5. Layer 5

In this layer there is only one fixed node whose function is to sum the inputs coming from layer 4. By equation [5]:

$$\sum_i \overline{W_i} f_i = \overline{W_1} f_1 + \overline{W_2} f_2$$

From the above equation obtained output layer 5. The output of layer 5 can be seen in table 10.

Table 10 Fifth Layer Output

Data To-	$\sum_i \overline{W_i} f_i$
1	5475.353205
2	5508.028296
3	5494.83
4	5476.477012
5	5591.91511
6	5615.173746
7	6094.222632

6. RMSE (Root Mean Squared Error)

RMSE is an alternative method for evaluating forecasting techniques. RMSE is the square of the estimation value difference with the observed value of a variable. If the RMSE value is smaller then the model or variable is more valid. The following RMSE calculations in the first stage of the 7 data entered. The following form of RMSE equation [5]:

$$RMSE = \frac{\sqrt{\sum_{i=1}^{n} (Y_i - (\sum_i \overline{W_i} f_i))^2}}{n}$$

From the above equation it can be seen under the RMSE obtained from the above calculation amounted to 20.26102

2.2 ANFIS Testing

This test is performed to obtain the values of the new a, b and c parameters from the last 7 months, 9 months and 11 months training. Of the three trainings will be sought the smallest RMSE value as an update parameter to be used at the time of testing. Testing is done with some epoch that is 20, 200 and 2000. The following test results can be seen in table 11 below:

Table 11 RMSE Test Results on Training

No	Data	Epoch		
		20	200	2000
1	7	51.46149	79.0668	2.69762
2	9	138.40789	136.70	146.7578
3	11	181.67	176.93	177.64972

From the test results in Table 4.8 it can be seen that at the time of epoch 2000 with the last 7 months yielded the smallest RMSE value with RMSE of 2.69762, at epoch 200 with the last 9 months yielded the smallest RMSE value of 136.70 and at epoch 200 with the last 11 months yielded the smallest RMSE value of 176.93. From the training obtained value of update parameters to be used for the purpose. the value of update parameters taken is the data that get the smallest RMSE value in each training conducted. From the test obtained is the final result of prediction that can be seen in table 12 below:

Table 12 Output Testing

No	Parameters			Output		
	7	9	11	7	9	11
1	3.5313E-07	3.534E-07	4.281E-07	6098	6098	6098

From the table can be seen below by using the parameter values a, b and c of the last 7 months obtained the smallest RMSE value that is amounted to 3.5313E-07 with grain prices ranged in Rp.6098.-.

3. CLOSING

In this section will explain the conclusions and suggestions of the research.

3.1. Conclusion

Based on the results of problem analysis, data collection, analysis of methods up to role and implementation, it can be concluded that research on the implementation of adaptive neuron fuzzy inference system (ANFIS) algorithm to predict the price of grain has been achieved, by obtaining RMSE 3.53137E-07 generated from data train last 7 months. The results answered the initial goal of this study to determine how to implement the ANFIS method to produce good predictive results.

3.2. Suggestion

Based on the results of the whole research it can be suggested for the next research to be better, ie the rules of determining the value of a, and c in the generalized-bell method to convert the actual value into the fuzzy membership value should be more noticed and adjusted on each parameter. In this study, there was a problem when one rule was applied to all parameters, because one of these parameters actually produced an error counting value due to the rule applied.

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