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Artificial Neural Network Backpropagation with Particle Swarm Optimization for Crude Palm Oil Price Prediction

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Abstract. Crude Palm Oil (CPO) is one of the plantation commodities provide the greatest contribution to Indonesia's foreign exchange. Because this plantation is one of the vegetable oil-producing plants with a high economic value. Therefore, the accuracy of the forecasting approaches in predicting the CPO prices is becoming the matter into concerns. This study aims to design a method of forecasting the price level for CPO. Neural Network Backpropagation (NN-BP) has been seen as a successful model in many systems recently. In this paper, we will apply Neural Network Backpropagation with a powerful stochastic optimization technique called Particle Swarm Optimization (PSO) to optimize the weight on NN-BP of Crude Palm Oil commodity price. The proposed method is a prediction model using an algorithm which combining particle swarm optimization (PSO) with Neural Network back-propagation (NN-BP) namely PSO-BP. The experimental results show that the proposed PSO–BP algorithm is better than standard Artificial Neural Network Backpropagation for accurate prediction and error convergence by providing better RMSE values.

Introduction

Indonesia is an agrarian country that relies on agricultural sector which as a source of livelihood and as a support for development. Crude Palm Oil (CPO) is one of the palm oil outcome process and better known as of crude palm oil. Palm oil has various advantages that are used as raw materials for various industries, both food and non-food industries. Based on data from the Indonesian Palm Oil Producers Association (Gapki) & Indonesian Ministry of Agriculture, palm oil still dominates in exports in 2016 of 26.57 million tons with a value of 18.6 billion US dollars. Palm oil is one of the plantation commodities that contribute the most to Indonesia's foreign exchange, Since this plantation is one of the vegetable oil-producing plants with a high economic value.

Driven by increasing global demand and rising profits, oil palm cultivation has been significantly enhanced by smallholder / self-help farmers as well as large entrepreneurs in Indonesia (with negative impacts on the environment and declining production of other agricultural products since many farmers turn to oil palm cultivation). However, both smallholders / self-help and permanent companies need data processing support and predictions that enable them to face the challenges they face to help them improve sustainable enterprises.

Prediction becomes an important foundation for long-term corporate planning. The accuracy and accuracy of the results of a prediction will have a good impact for the company in increasing its chances in achieving better investment. In the business world to gain something in the future there

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needs to be a calculation that needs to be done to minimize errors that will occur at that time. Efforts of reducing uncertainty are commonly practiced by forecasting techniques by applying a suitable method [1].

Based on the above situation for CPO price at the spot of Sumatra experienced fluctuations in the price of up and down due to the influence of global economic conditions, where the fluctuation rate due to both excess and shortage of production so that greatly affect the price changes in the international market.

Research conducted by Joko S. Dwi Raharjo [2] apply the PSO method with Neural Network for inflation rate. Test results in this study indicate that the value produced by using the PSO and Neural Network method is better that is 0.157 than testing without using optimization method is 0.181.

Azme Khamis [3], undertook research to identify the appropriate model between the Multiple Linear Regression (MLR) model and the Artificial Neural Network model (JST) to predict the price of Crude Palm Oil Malaysia (CPO). Malaysian palm oil is predicted by Malaysia's three other major commodity prices, namely the price of natural rubber, black pepper prices and the price of cocoa beans. The analysis used weekly data on prices from January 2004 to December 2013. This method is compared to get the best model for predicting crude palm oil prices. The results show that the ANN model is higher than the MLR model of 20.61%. The mean value of squared error (MSE) in the ANN model is also lower than the MLR model. Therefore, a better ANN model is used to serve as an alternative model in estimating the price of palm oil (CPO) versus the MLR model.

This study aims to design a method of estimating the price level for CPO. The proposed method is a prediction model using Artificial Neural Network with Particle Swarm Optimization for optimization the prediction of the price of palm oil (CPO).

2. Research Method

2.1. Data collection

The research method used in this research is the experimental method. Experimental method is done on the data obtained, using Neural Network method with BackPropagation structure to then implemented in a supporting application program to know the result of MSE value (Mean Square Error) and RMSE (Root Mean Square Error) is lower so it can get the price prediction value right. Several stages of experimental research carried out in this study are shown in figure 1.

The data obtained are data sourced from the Commodity Futures Trading Supervisory Agency (BAPPEBTI) or from the www.bappebti.go.id website in the form of CPO commodity data. This data manifests daily data with a total of 2115 records from January 2005 to March 2017. The data is a univariate time series data, ie data that only has an attribute without any other attributes that affect.

2.2. Data Processing

The data used in this research is a univariate model. The univariate data will be processed into a multivariate model. The patterns used in converting univariate data to multivariate.

Prior to experimenting and testing, preprocessing data needs to be done to scaling (normalizing) the inputs and targets. In practice, the data used in the study has a different location, so normalization is done to group data in a scale or a certain range so as to facilitate the next process. All variables will be normalized in the range 0-1 [4]. The following is the normalization equation.

$$x' = \frac{x - \min\ value}{\max\ value - \min\ value} \quad (1)$$

Information:

x = Data
x' = Normalized
min value = Minimum Value
max value = Maximum Value

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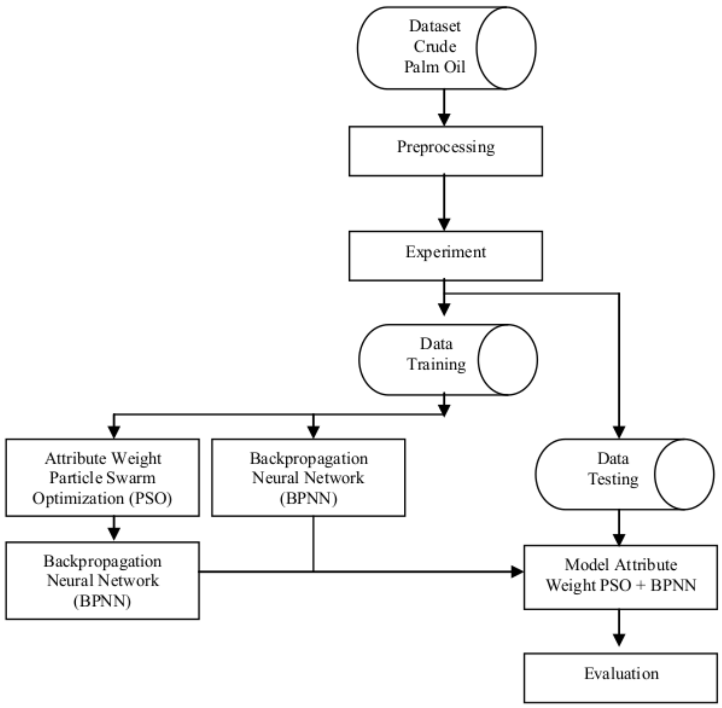

Figure 1. Stages Conducted Experiments

2.2.1. Artificial Neural Network (ANN). Artificial Neural Network (ANN) is a concept of knowledge engineering from the branch of science of Artificial Intelligence (AI) designed by adopting the human nervous system, where the main processor of the human nervous system is in the brain. The human brain contains millions of nerve cells (neurons) in charge of processing information. The ability of ANN in learning is designed in such a way as the performance of the human brain, in which humans have the ability to process information, remember, and perform calculations [5]. Some problems that can be solved with ANN are prediction, classification, optimization and pattern recognition. Based on the abilities they have, the results of ANN learning can be used to find solutions to a problem. Figure 2 shows the ANN Structure.

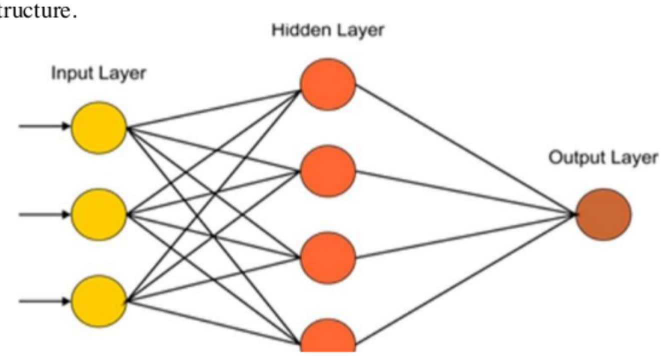

Figure 2. The ANN Structure

The structure of the neural network consists of:

a. Input Layer, contains nodes that each store an unchanged input value in the training phase and can only change if new input values are given. The nodes in this layer depend on the number of inputs of a pattern.
b. Hidden Layer, this layer never appears so called the hidden layer. However, all processes in the training phase and introduction phase are carried out in this layer. The number of layers depends on the architecture to be designed, but generally consists of a hidden layer layer.
c. Output Layer, serves to display the calculation of the system by the activation function in the layer hidden layer based on the received input.

2.2.2. Backpropagation. Backpropagation is the most popular algorithm that has the ability to perform a learning prediction in data mining, this method was first introduced by Bryson and Ho in 1969 and re-developed in 1986 by Rumelhart and McClelland. Backpropagation algorithm is a supervised learning algorithm with multiple layers (multilayer). In supervised learning, there are targets that will be compared with the network output. When the input network is input signal, this signal goes to the units in the hidden layer, then forwarded to the units in the output layer. If the output signal on the network is not the same as the target, it will be done backward step on the hidden layer (hidden) forwarded to the input layer (input). Figure 3 shows the Backpropagation Structure.

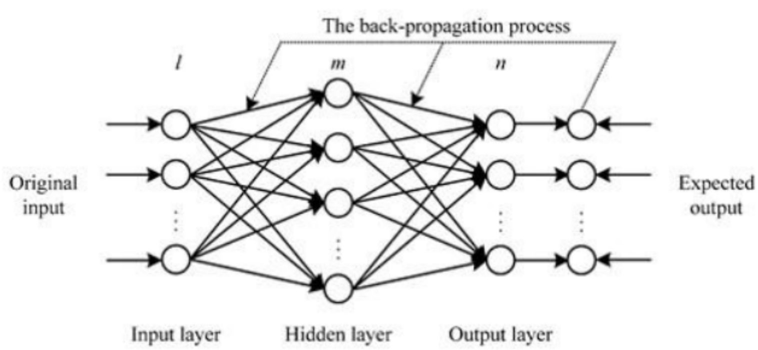

Figure 3. Backpropagation Structure

Backpropagation learning process is done by adjusting the weight of artificial neural networks with the backward (Backward) based on the error value in the learning process. To get the error value, forward propagation must be done first. There are 3 phases in the learning process Backpropagation algorithm are:

a. Phase I, forward propagation, the input pattern is calculated forward from the input layer to the output layer using a predefined activation function.
b. Phase II, backward propagation, the difference between the output of the network and the desired target is an error. The obtained error is propagated backwards from the network directly related to the neuron in the output layer to obtain the weight change rate.
c. Phase III, weight change, weight modification to decrease the error value that occurs based on the rate of weight changes that have been obtained in the previous phase.

2.2.3. Particle Swarm Optimization (PSO). Swarm is a collection of some individuals who declare a potential solution in the search space. Each of these solutions will be evaluated using the fitness function. Every individual has a memory of the best position ever passed (Pbest). The best solution of all particles in the population is the best global solution (Gbest). In each iteration of the solution search, each individual will update his position using information from Pbest and Gbest so that all

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individuals will provide convergent solutions and can achieve optimal solutions in the solution search space [7]. In the PSO technique there are several ways to perform optimization such as increasing the weight attribute (attribute weight) to all attributes or variables used [8]. A particle is implemented as a vector with the position of an i particle represented as x_i = x_i1, x_i2, x_i3, ..., x_id and the velocity of the i particle is represented as v_i = v_i1, v_i2, v_i3, ..., v_id.

Equation (2) is a process of updating the speed of each particle and equation (3) is an update of the position of each particle.

$$v_{i,j}^{n+1} = w.v_{i,j}^{n} + c_1 r_1 (p_{i,j}^{n} - x_{i,j}^{n}) + c_2 r_2 (p_{g,j}^{n} - x_{i,j}^{n}) \tag{2}$$

$$x_{i,j}^{n+1} = x_{i,j}^{n} + v_{i,j}^{n+1} \quad j = 1,2,3,\dots,d \tag{3}$$

Where :

p_i^n = Position vector of i-th iteration best obtained through the n-th iteration
p_g^n = The best position of all particles (in the population).
c1 and c2 = Constant acceleration with a positive value,
r1 and r2 = Random function in the range [0,1].
weights w = is the most important parameter for the convergence of PSO.

At the beginning of the training, the value of the weight should be reduced quickly to find the optimal global value but when around the global optimum the weight value should be reduced slowly

2.2.4. *Cross Validation*. Cross Validation is a validation technique by dividing data randomly into k section and each part will be done classification process. Cross validation will experiment as much as k. The data used in this research is training data to find the overall error rate value. In general, the test k is performed 10 times to estimate the accuracy of estimation. In this study the value of k used is 10 or called 10-fold cross validation. [9]

Each trial will use one data test and k-1 part will be training data, then the data testing will be exchanged with one training data so that for each experiment will get different data testing. Data training is the data that will be used in doing learning while data testing is data that has not been used as learning and will serve as the data testers the truth or the accuracy of learning outcomes.

2.2.5. *Root Means Square Error (RMSE)*. To see the predicted results and know the accuracy of the predicted results that have been made to the actual data need to be done an evaluation. Some methods can be used to calculate forecasting errors such as Root Mean Squared Error (RMSE). RMSE is a fairly common method used in evaluating prediction performance. By using RMSE, the existing error indicates how much difference the estimation results with the result to be estimated. The existence of randomness to the data or because it does not contain more accurate estimates is what makes the difference in results. RMSE is rooted in the value of MSE that has been searched for before. RMSE is used to find the accuracy value of the predicted result with historical data by using the formula shown with the error value. The smaller the value produced the better the predicted results are done. The RMSE formula is represented in equation [10].

$$RMSE = \sqrt{\frac{\Sigma(yt - \widehat{yt})^2}{n}} \tag{4}$$

where:

yt = Actual value of the index
n = Number of samples
$\hat{y}_t$ = Index prediction value

3. Results and Discussion

In the first experiment the author used the Neural Network algorithm first without using Particle Swarm Optimization for optimization.

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The dataset in this study used 584 records and 5 predictor attributes that have been normalized. The method used for testing this data is Articifial Neural Network and dataset that has been converted into multivariate data that have been normalized. Data is normalized and divided into several periods ie 1 period to 5 periods. The experiment was conducted several times to get the architecture of Artificial Neural Network by changing the value of the number of Neurons in Hidden Layer, Training Cycle, Learning Rate and Momentum so that the best value for each of them is shown in table 1.

Table 1. Best Value for Artificial Neural Network

Neuron	Training cycle	Learning Rate	Momentum	RMSE
6	500	0,1	0,1	0,032
6	500	0,1	0,2	0,032
6	500	0,1	0,3	0,031
6	500	0,1	0,4	0,032
6	500	0,1	0,5	0,031
6	500	0,1	0,6	0,036
6	500	0,1	0,7	0,042
6	500	0,1	0,8	0,055
6	500	0,1	0,9	0,074

Based on the results of the above experiments to find the best model in Artificial Neural Network architecture is the hidden layer 6 neurons, training cycle 500, learning rate 0.1 and momentum 0.5 can be seen RMSE value of 0.031. The Artificial Neural Network architecture model that can be produced can be seen in the figure 4.

Further testing by adding the PSO method for weighting can be seen in table 2.

Table 2. Test Results Best Global Value Weight

Population Size	***Max of Generation***	***Inertia Weight***	***Local Best Weight***	***Global Best Weight***	**RMSE**
8	30	1,0	0,2	0,1	0,026
8	30	1,0	0,2	0,2	0,026
8	30	1,0	0,2	0,3	0,026
8	30	1,0	0,2	0,4	0,026
8	30	1,0	0,2	0,5	0,026
8	30	1,0	0,2	0,6	0,026
8	30	1,0	0,2	0,7	0,027
8	30	1,0	0,2	0,8	0,026
8	30	1,0	0,2	0,9	0,026
8	30	1,0	0,2	1,0	0,025

Based on table 2 above we get the best parameter result for weighting by using Particle Swarm Optimization is population value = 8, max value of generation = 30, inertia weight value = 1.0, local best weight value = 0,2 and global value best = 1.0 with the lowest RMSE value of 0.025.

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The result of the selected attribute through weight optimization process with PSO has five attributes. The attribute weighting results can be seen in Table 3.

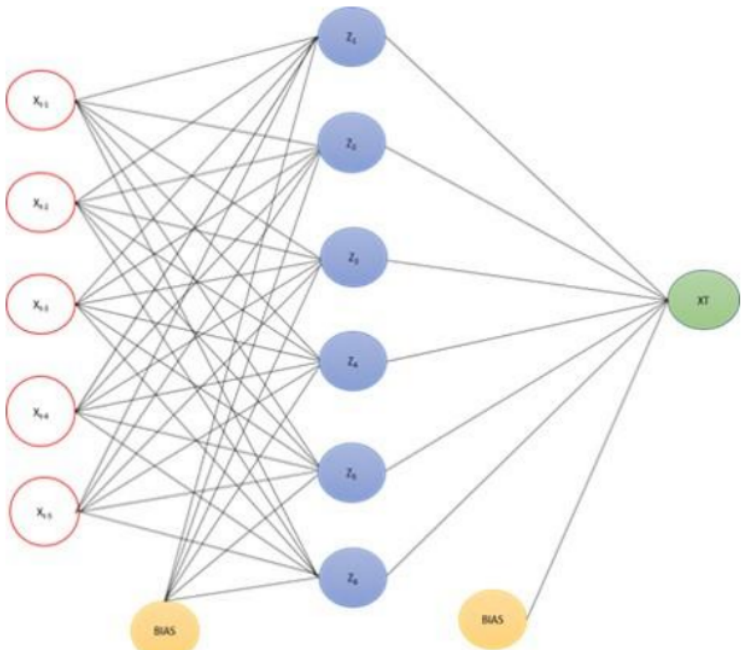

Figure 4. Architecture Neural Network

Table 3. Weight Attributes PSO

Attibute	*Weight (Bobot)*
Xt-1	0,244
Xt-2	0,494
Xt-3	0,844
Xt-4	0,379
Xt-5	0,456

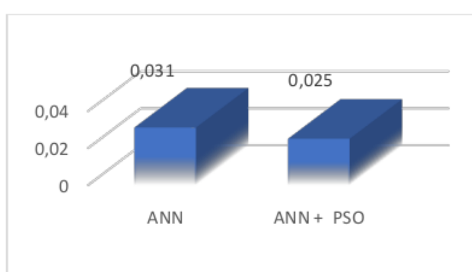

Figure 5. Comparison Value RMSE ANN and ANN+PSO

Based on the graph above, shows that RMSE values obtained from experiments using ANN and PSO as an optimization resulted in a lower RMSE is 0.025 compared to experiments using only the results of RMSE ANN 0,031.

4. Conclusion

Based on the experimental results and discussion on this study, it may be concluded as follows: Artificial Neural Network algorithm can be applied to the price of Crude Palm Oil (CPO). Particle Swarm Optimization (PSO) can minimize RMSE value to predict CPO price by using Artificial Neural Network algorithm. RMSE value of Predicted CPO price without PSO is 0,031 and even smaller 0,025 with PSO based ANN.

Related to the optimization method used in this research, the optimization method used can be done and developed with the use of other optimization methods such as: Genetic Algorithm (GA), Chi Square, Ant Colony Optimization (ACO), Adaboost and others. The method and result of this research is expected to be used by businessmen and government in determining the price for comoditi of CPO in the future.

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