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To cite this article: Nurliana Nasution *et al* 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **420** 012088

IOP Conf. Series: Materials Science and Engineering **420** (2018) 012088 doi:10.1088/1757-899X/420/1/012088

Polak-Ribiere updates analysis with binary and linear function in determining coffee exports in Indonesia

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Abstract. The purpose of this study is to determine and predict coffee exports in Indonesia based on the main destination countries for years to come. The results of this study are expected to be widely used for both government and private sector as an evaluation material in coffee, economic and business development. The data used in this study is Coffee Exports In Indonesia based on the main destination countries in 2006-2015. Data processed from customs documents of the Directorate General of Customs and Excise cited from Indonesia Statistics Publication. This research uses artificial neural network Polak-Ribiere updates which will be combined with bipolar activation function and linear function. The architectural model used there are 4, among others: 8-10-15-1, 8-15-10-1, 8-15-30-1 and 8-30-15-1. The best architectural model of the 4 models used is 8-10-15-1 with error rate of 0.001-0.06, alpha = 0.001, beta = 0.1, delta = 0.01 and gama = 0.1. The resulting accuracy is 86%.

1. Introduction

Coffee is a commodity that belongs to the category of strategic commodities in Indonesia. Coffee has a high economic value among other plantation crops and plays an important role as a source of foreign exchange, especially the state of Indonesia. Coffee plants can be a source of income for the people through the export of raw or processed beans from coffee beans. Coffee is also one of the world's most cultivated commodities in more than 50 countries [1]. Coffee is often used as an opening for initiating long day activities. Those who like to drink coffee reason, that drinking coffee can make the mind fresher and improve mood, which is very good to start the activity in the morning. According to experts, coffee contains hundreds of biologically active compounds that are able to maintain the health of the human body and be able to reduce the risk of death caused by heart, stroke, and even diabetes [2]. Once the importance of coffee, so make the coffee market continues to grow over time, one of which is driven by consumer preference[3][4][5].

In Indonesia itself, coffee cultivation has been done for a long time. Moreover, the microclimate in Indonesia is ideal for growth and coffee production. So Indonesia is known as the 3rd largest coffee producing country in the world. The highest coffee export value in Indonesia ever occurred in 2012 amounted to USD 1.5 billion, indicating its high international appeal[6]. Therefore, it is necessary to predict coffee exports for years to come. Important predictions are made to know something that will happen in the future by utilizing various relevant information at a previous time (historically) through the scientific method [7]–[10], so the government has a reference in determining the right policy so that Indonesia can still export coffee to destination countries. Export of coffee in Indonesia based on destination countries can be seen in table 1.

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Table 1. Export of coffee in Indonesia by country's of destination

Country Of Destination	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Japan	67.012,3	51.725,3	52.992,2	53.678,5	59.170,9	58.878,9	51.438,4	41.920,4	41.234,3	41.240,1
Singapore	14.558,1	12.630,6	7.237,0	7.305,8	6.079,0	6.240,4	9.154,1	8.677,9	7.725,9	9.212,9
Malaysia	8.500,7	12.407,5	17.370,4	17.803,2	26.200,1	26.382,1	33.134,1	40.580,4	29.136,2	38.347,5
India	11.172,7	8.294,9	12.085,0	9.950,7	9.733,3	12.162,4	19.884,0	18.292,4	14.434,3	19.303,0
Egypt	11.721,7	5.469,0	10.109,0	10.079,8	12.024,7	10.013,9	17.594,6	17.538,3	15.694,6	20.854,2
Morocco	7.627,2	6.247,8	6.860,4	7.900,2	8.369,1	10.013,0	11.268,6	12.874,3	10.418,7	11.069,1
Algeria	14.073,0	8.379,6	23.205,6	26.531,9	10.303,2	7.298,4	10.488,9	24.265,5	10.590,6	16.911,6
USA	85.503,2	66.222,5	65.646,0	71.603,7	63.048,0	48.094,7	69.651,6	66.138,1	58.308,5	65.481,3
English	12.245,8	8.822,6	15.125,3	16.425,5	24.343,1	14.868,4	16.312,4	20.781,0	14.349,2	21.052,6
German	60.225,2	43.074,1	89.600,9	78.876,0	63.688,4	26.461,0	50.978,2	60.418,5	37.976,7	47.662,4
Italy	27.635,5	19.529,4	30.213,4	36.188,4	26.770,7	27.344,4	29.080,8	38.152,5	29.745,5	43.048,3
Romania	8.743,9	4.613,4	4.565,9	4.816,9	2.219,4	1.497,0	1.362,0	507,6	397,9	492,6
Georgia	9.510,3	6.455,6	9.238,4	11.486,7	9.077,4	6.893,0	9.133,5	12.029,6	10.277,1	12.167,5
Others	72.979,1	66.559,2	123.602,8	157.383,1	111.693,8	89.915,0	117.529,6	169.962,8	102.460,8	152.769,6
Amount	**411.508,7**	**320.431,5**	**467.852,3**	**510.030,4**	**432.721,1**	**346.062,6**	**447.010,8**	**532.139,3**	**382.750,3**	**499.612,7**

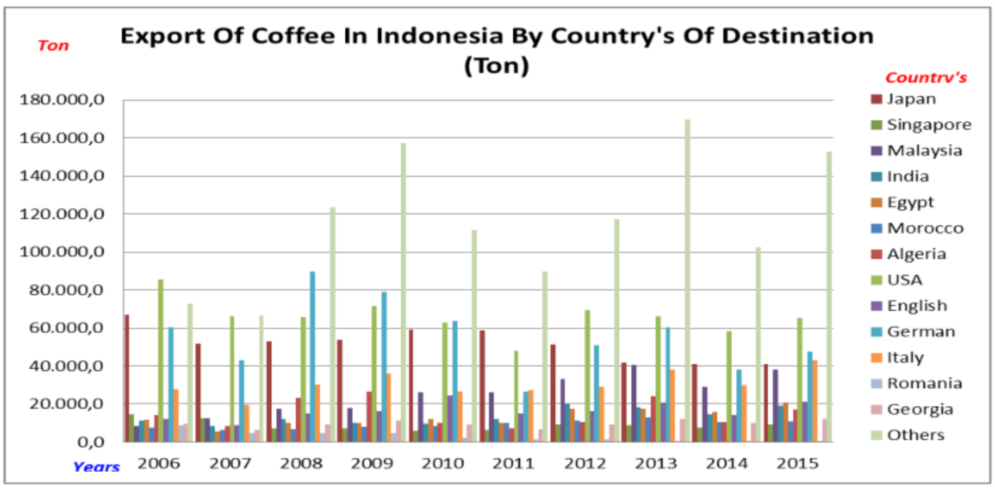

Figure 1. Graph export of coffee in Indonesia by country's of destination

In this study, the technique used to predict the artificial neural network with the Polak-Ribiere[11], [12] Updates algorithm to be combined with the binary (logsig) and linear (purelin) functions. It is hoped that using this method will get the desired prediction result because the algorithm is a network training function that updates the weight and corresponding bias values[13][14]. Binary function (logsig) is an activation function used to bridge the comparison between the number of values of all the weights that will come with the input value with the threshold value. In ANN the activation function used must meet

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several conditions, namely: continuous, easy to distinguish and is a function that does not go down. One function that meets three frequently used requirements is a binary sigmoid function that has a range (0.1), and a linear identity function. Binary sigmoid function (logsig) is used as a hidden layer activation function, while linear (purelin) as an output layer activation function in Polak-Ribiere Updates later [15]. In previous research[16] optimizing coffee cultivation and its impact on economic growth and export earnings of producer countries such as Saudi Arabia using LINGO optimization software. The empirical results of the study revealed that Saudi Arabia's enormous potential for expanding coffee cultivation in the south and southwest has been increasing. [17] Conducting research on how to foster sustainable coffee production by analyzing the coffee evolution and its impact on how sustainability is being applied by coffee farmers, as well as changes generated in agriculture and in the production community.

2. Theory

2.1. Artificial Intelligence

Artificial Intelligence is one area that is quite reliable in solving problems such as forecasting[18][19]. AI is very important and needed in various disciplines that include a number of areas such as expert systems[20], [21], natural language processing, speech recognition, robotics, sensor systems, computer vision, machine learning, Intelligent Computer and others[22]–[26]. Artificial Intelligence (AI) follows/imitates the characteristics and analogy of thinking of human intelligence/Intelligence, and applies it as an algorithm known by computers. AI deals with the use of machines to solve complex problems in a more humane way [27][28].

2.2. Polak-Ribiere updates

Polak-Ribiere updates is one part of the conjugate gradient method. In practical calculations, the Polak-Ribiere method is generally believed to be one of the most efficient methods of conjugate gradient [12]. A conjugate gradient algorithm for systems of large-scale nonlinear equations is designed by the following steps: (i) A three-terms conjugate gradient direction d_k is presented where the direction possesses the sufficient descent property and the trust region property independent of line search technique; (ii) A backtracking line search technique along the direction is proposed to get the step length αk and construct a point; (iii) If the point satisfies the given condition then it is the next point, otherwise the projection-proximal technique is used and get the next point [11].

2.3. Binary Function (logsig) and Linier Function (purelin)

In ANN the activation function used must meet several conditions, namely: continuous, easy to distinguish and is a function that does not go down. One of the functions that meet the three requirements so often used is a binary sigmoid function that has a range (0.1), and linear identity function. Binary sigmoid function (logsig) is used as a hidden layer activation function, while linear (purelin) as an output layer activation function in the backpropagation later. Here's an explanation of linear function and binary sigmoid function [9]:

a. Linear Function (purelin)

The Linear function produces an output value equal to its input value. The Linear function can be formulated as follows:

$$y = f(x) = x \qquad \text{with : } f'(x) = 1 \tag{1}$$

b. Binary Function (logsig)

Binary function produces output values ranging from 0 to 1. Therefore, this function is often used for artificial neural networks that require an output value located at intervals of 0 to 1. Binary sigmoid function is formulated as follows:

$$y = f(x) \frac{1}{1+e^{\sigma x}} \quad \text{with : } f'(x) = \sigma f(x)\,[1 - f(x)] \qquad (2)$$

3. Results And Discussion

3.1. Data Collection

The data used in this study is the export coffee data in Indonesia based on the main destination countries in 2006-2015 (can be seen in Table 1 previous discussion). Data processed from customs documents of the Directorate General of Customs and Excise quoted from the Publication of Statistics Indonesia. Coal export data will be divided into 2 parts, 2006-2013 data is used as input training data, while 2014 data are used as training target data. Data 2007-2014 is used as training data input, while data 2015 is used as a target test data.

3.2. Normalization Data

The data will be normalized using the following formula.

$$x' = \frac{0.8(x-a)}{b-a} + 0.1 \qquad (3)$$

Table 2. Normalization of Training Data (Year 2006-2013/Target 2014)

Data	2006	2007	2008	2009	2010	2011	2012	2013	Target
Pattern 1	0,41428	0,34216	0,34814	0,35138	0,37729	0,37591	0,34081	0,29590	0,29266
Pattern 2	0,16681	0,15771	0,13227	0,13259	0,12680	0,12756	0,14131	0,13906	0,13457
Pattern 3	0,13823	0,15666	0,18008	0,18212	0,22173	0,22259	0,25445	0,28958	0,23559
Pattern 4	0,15084	0,13726	0,15514	0,14507	0,14404	0,15550	0,19193	0,18443	0,16622
Pattern 5	0,15343	0,12393	0,14582	0,14568	0,15485	0,14537	0,18113	0,18087	0,17217
Pattern 6	0,13411	0,12760	0,13049	0,13540	0,13761	0,14536	0,15129	0,15886	0,14728
Pattern 7	0,16452	0,13766	0,20761	0,22330	0,14673	0,13256	0,14761	0,21261	0,14809
Pattern 8	0,50152	0,41056	0,40784	0,43595	0,39558	0,32503	0,42674	0,41016	0,37322
Pattern 9	0,15590	0,13975	0,16948	0,17562	0,21297	0,16827	0,17508	0,19617	0,16582
Pattern 10	0,38226	0,30134	0,52086	0,47026	0,39860	0,22296	0,33864	0,38317	0,27730
Pattern 11	0,22851	0,19026	0,24067	0,26886	0,22443	0,22713	0,23532	0,27812	0,23846
Pattern 12	0,13938	0,11989	0,11966	0,12085	0,10859	0,10519	0,10455	0,10052	0,10000
Pattern 13	0,14299	0,12858	0,14171	0,15232	0,14095	0,13064	0,14121	0,15488	0,14661
Pattern 14	0,44244	0,41215	0,68128	0,84065	0,62509	0,52234	0,65262	0,90000	0,58153

Table 3. Normalization of Testing Data (Year 2007-2014/Target 2015)

Data	2007	2008	2009	2010	2011	2012	2013	2014	Target
Pattern 1	0,34216	0,34814	0,35138	0,37729	0,37591	0,34081	0,29590	0,29266	0,29269
Pattern 2	0,15771	0,13227	0,13259	0,12680	0,12756	0,14131	0,13906	0,13457	0,14159
Pattern 3	0,15666	0,18008	0,18212	0,22173	0,22259	0,25445	0,28958	0,23559	0,27904
Pattern 4	0,13726	0,15514	0,14507	0,14404	0,15550	0,19193	0,18443	0,16622	0,18919
Pattern 5	0,12393	0,14582	0,14568	0,15485	0,14537	0,18113	0,18087	0,17217	0,19651
Pattern 6	0,12760	0,13049	0,13540	0,13761	0,14536	0,15129	0,15886	0,14728	0,15035
Pattern 7	0,13766	0,20761	0,22330	0,14673	0,13256	0,14761	0,21261	0,14809	0,17791
Pattern 8	0,41056	0,40784	0,43595	0,39558	0,32503	0,42674	0,41016	0,37322	0,40706
Pattern 9	0,13975	0,16948	0,17562	0,21297	0,16827	0,17508	0,19617	0,16582	0,19745
Pattern 10	0,30134	0,52086	0,47026	0,39860	0,22296	0,33864	0,38317	0,27730	0,32299
Pattern 11	0,19026	0,24067	0,26886	0,22443	0,22713	0,23532	0,27812	0,23846	0,30122
Pattern 12	0,11989	0,11966	0,12085	0,10859	0,10519	0,10455	0,10052	0,10000	0,10045
Pattern 13	0,12858	0,14171	0,15232	0,14095	0,13064	0,14121	0,15488	0,14661	0,15553
Pattern 14	0,41215	0,68128	0,84065	0,62509	0,52234	0,65262	0,90000	0,58153	0,81888

3.3. Analysis

Before the training, the parameters of the desired parameters are determined to obtain optimal results. Parameters commonly used in Matlab applications for training and testing can be seen in the following code:

```
>> net=newff(minmax(P),[10,15,1],{'logsig','purelin','logsig'},'traincgp');
>> net.trainParam.epochs=15000;
>> net.trainParam.show=25;
>> net.trainParam.showCommandLine=0;
>> net.trainParam.showWindow=1;
>> net.trainParam.goal=0;
>> net.trainParam.time=inf;
>> net.trainParam.min_grad=1e-6;
>> net.trainParam.max_fail=5;
>> net.trainParam.searchFcn='srchcha';
>> net.trainParam.alpha=0.001;
>> net.trainParam.beta=0.1;
>> net.trainParam.delta=0.01;
>> net.trainParam.gama=0.1;
>> net=train(net,P,T)
```

Explanation :

net.trainParam.epochs : Maximum number of epochs to train
net.trainParam.show : Epochs between displays (NaN for no displays)
net.trainParam.showCommandLine : Generate command-line output
net.trainParam.showWindow : Show training GUI
net.trainParam.goal : Performance goal

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net.trainParam.time	: Maximum time to train in seconds
net.trainParam.min_grad	: Minimum performance gradient
net.trainParam.max_fail	: Maximum validation failures
net.trainParam.searchFcn	: Name of line search routine to use
net.trainParam.scal_tol	: Divide into delta to determine tolerance for linear search.
net.trainParam.alpha	: Scale factor that determines sufficient reduction in perf
net.trainParam.beta	: Scale factor that determines sufficiently large step size
net.trainParam.delta	: Initial step size in interval location step
net.trainParam.gama	: Parameter to avoid small reductions in performance, usually set to 0.1 (see srch_cha)

3.4. Results

This research uses 4 architectural models. Among others are 8-10-15-1, 8-15-10-1, 8-15-30-1 and 8-30-15-1. Of the 4 models of this architecture, the best architecture is 8-10-15-1 with an accuracy of 86%.

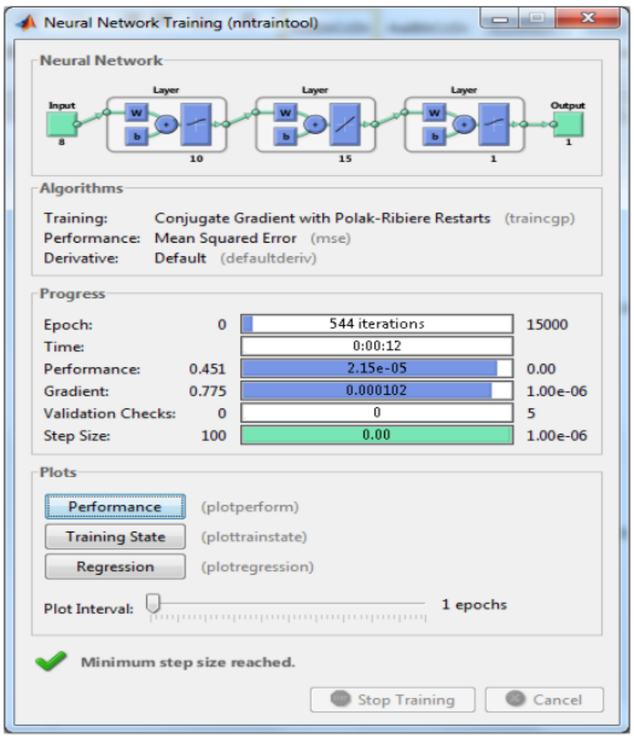

Figure 2. Training with architecture 8-10-15-1

Table 4. Architectural results Polak-Ribiere with binary and linier function

Polak-Ribiere With Binary And Linier Function			
Architecture	**Epoch**	**MSE**	**Accuracy**
8-10-15-1	544	0,0176404485	86%
8-15-10-1	308	0,0579365628	50%
8-15-30-1	245	0,0466028618	50%
8-30-15-1	205	0,0482220739	57%

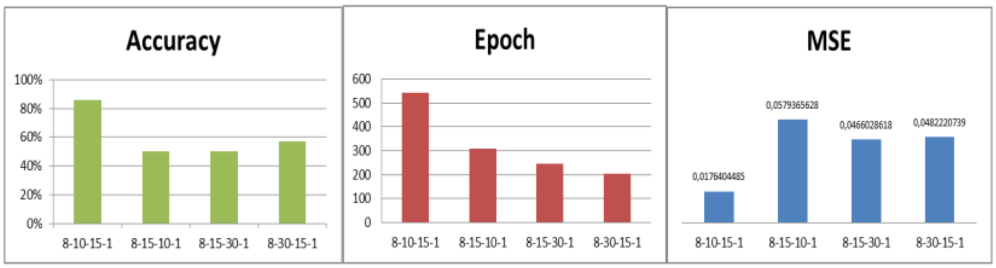

Figure 3. Graph of Accuracy, Epoch and MSE

Figure 3 illustrates the comparison of the accuracy, epoch and MSE levels of each architecture model used with the binary function and linear in the polak-ribiere updates algorithm.

Table 5. Prediction results 5 years ahead (the year 2016-2020)

Country's Of Destination	2016	2017	2018	2019	2020
Japan	37.286,5	24.719,4	24.256,9	23.920,4	23.676,6
Singapore	6.031,7	13.722,4	18.004,9	21.897,5	23.480,8
Malaysia	35.059,5	11.734,6	16.922,8	21.672,7	23.447,8
India	17.376,3	13.486,5	17.584,1	21.917,9	23.465,4
Egypt	17.947,4	13.486,5	18.089,0	21.754,5	23.450,0
Morocco	11.818,2	13.655,0	18.028,9	21.965,6	23.465,4
Algeria	14.939,9	13.587,6	17.896,7	21.829,4	23.458,8
USA	58.890,8	59.135,0	43.770,5	30.152,6	24.323,4
English	17.585,7	13.132,8	17.355,6	21.652,3	23.454,4
German	43.092,1	38.010,6	31.807,5	26.331,6	23.929,6
Italy	38.847,4	10.454,3	16.237,5	21.236,8	23.399,4
Romania	2.567,4	13.840,3	17.944,7	22.013,3	23.485,2
Georgia	12.103,7	13.671,8	18.377,6	21.843,0	23.452,2
Others	137.332,5	106.639,8	70.726,5	38.836,8	25.225,4
Amount	**450.879,0**	**359.276,5**	**347.003,2**	**337.024,5**	**331.714,7**

4. Conclusion

The conclusions that can be drawn from this research are:

a. The 8-10-15-1 architecture model can predict with 86% Accuracy.
b. The activation function, network model, and parameters used greatly affect the level of accuracy and quality of prediction.
c. It is hoped that this result will help the government in determining the right policies in the future related to the export of coffee in Indonesia to the main destination countries.

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