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Application of Predictions for the Total Productivity of Competency Certificates Electrical Engineering Staff at PT. Eleska Iatki Using Artificial Neural Network Backpropagation Algorithm

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Abstract: ***The productivity value is a critical performance assessment criterion for Competency Certification Institutes LSK for electrical engineering personnel in Indonesia, overseen by the Directorate General of Electricity DJK. This study aims to predict the productivity of competency certificates issued by PT Eleska Iatki using an Artificial Neural Network ANN with the Backpropagation algorithm. Accurate predictions are essential for developing business strategies and maintaining high performance amidst competitive pressures. Data from 2018 to 2022, consisting of certificate issuance records, were utilized. The study's methodology included data collection, preprocessing, prediction modeling, and accuracy testing, resulting in a prediction accuracy of 91.3 with a Mean Absolute Percentage Error MAPE of 9.7***

Keywords: Prediction, Competency Certificate, Artificial Neural Network, Backpropagation Algorithm, Mean Absolute Percentage Error

1. Introduction

The Competency Certification Institute (LSK) for Electrical Engineering Personnel is a Business Entity that carries out the government's mandate starting from Law number 30 of 2009[1]up to its derivative Job Creation Law number 11 of 2020 article 44 paragraph 6[2]. The law states that every electrical engineering worker is required to have a competency certificate. This regulation aims to create Electricity Safety (K2), so many business entities supporting electricity services have emerged. Ministry of Energy and Mineral Resources cq. DJK supervises these business entities to maintain compliance with applicable regulatory provisions[3].

In carrying out its supervision, DJK refers to performance assessment guidelines, to obtain output in the form of awards or sanctions[3]. One of the performance assessment criteria is productivity with the parameter of recapitulating the number of certificates issued in a certain period. With a high number of certificates compared to other LSKs, the performance assessment value obtained is greater.

To achieve competency certificate productivity, an accurate prediction process is needed. The prediction results will be used by Company management to determine various effective and efficient strategies for achieving annual targets/turnover. The target/turnover amount will be included in the annual Company Budget Work Plan (RKAP). After the target is determined, management will also carry out risk mitigation to achieve the target. So it can be explained as:

Figure 1: Relationship between predictions and performance assessment

Business entity productivity is a measure that states how well resources are managed and utilized to achieve optimal results and performance in the business entity[3].

Productivity predictions play a very important role, so it is necessary to use technology that is in line with current developments. Prediction can be interpreted as forecasting or

forecasting activities. Forecasting is guessing conditions in the future based on data from the past and data that can influence the situation to be predicted. [4].

Predictions are closely related to accuracy and error. A good prediction is a prediction that has a high level of accuracy with a low error value. Currently, many predictive engineering methods have been developed, so considerations must be taken in choosing a prediction method. The following are the advantages and disadvantages of several prediction methods:

Table 1: Prediction Method

No	Method	Excess	Weakness
1	Support Vector Machines (SVM)	Low Error Rate	Slow when training with large data sets
2	K-Nearest Neighbor (KNN)	Effective for large data, reliable for data that has a lot of noise	Need to calculate testing data one by one against all training data, sensitive to pre-processing
3	Artificial Neural Network (ANN)	Error tolerance on large training data	It is difficult to know how many neurons and layers are needed and learning is slow

ANN is one of the best prediction methods[5], particularly for predicting certificate productivity. In the ANN method, several algorithms have been used, one of which is backpropagation. ANN has unique advantages and better performance in handling nonlinear statistical data modeling and prediction[6]. The Backpropagation algorithm is one of the most popular, effective, and easy-to-learn procedures on complex multilayer networks to optimize Artificial Neural Network (ANN) training. Backpropagation carries out supervised learning which is used in multi-layer networks consisting of several hidden layers that aim to minimize errors in the network that produces output.[7]. The Backpropagation model is considered to have high-accuracy results in predicting burst pressure in corroded pipes[6].

The types of model performance evaluation from scientific data consist of Mean Absolute Error (MAE), Mean Square Error (MSE), Root Mean Squared Error (RMSE), and Mean Absolute Percentage Error (MAPE)[8]. However, when measuring the goodness of the model in this research, the Mean Absolute Percentage Error (MAPE) will be used.

Based on the background that has been described, the researcher conducted research with the title Application of Productivity Prediction Number of Competency Certificate for Electrical Engineering Personnel at PT Eleska Iatki Using Artificial Neural Network Backpropagation Algorithm. Through the algorithm that has been chosen, researchers are expected to be able to produce better accuracy values to determine strategies for achieving the Company's goals in the future.

2. Research Methods

The research was carried out and carried out using productivity data on the number of certificate issuances at PT Eleska Iatki from 2018 to 2022 from various types of certification implementation. The main aim of this research is to make it easier for company management to predict the number of certificates so that they can determine future targets, choose marketing strategies, mitigate future risks, and estimate the costs of procuring paper certificates based on the previous year's data.

Data collection methods used include:

1) Interview
Data obtained from interviews with functions related to the number of certificate productivity at PTEleska Iatkinamely Operations Director, Certification Manager, and Certificate Issuance Staff. The data obtained from the interview results are the number of certificates issued per month and various types of certification from 2018 to 2022. This data will be used for a dataset which will later be used for data mining and used as a model in this research.

2) Document Study
Document studies are carried out by reading, and analyzing several journals, reports, applicable regulations, and other official documents and sources from the internet. This document study was carried out to find the right method, by the nature of the data obtained and easy to predict the number of certificate productivity.

3) Observation
Observations are carried out by observing in more detail how important and useful productivity predictions are in the company. The Company's level of interest in this prediction is related to the needs of other supporters which influence each other so all preparations must be anticipated.

The design process in this research uses the Artificial Neural Network (ANN) method and model using the Backpropagation Algorithm. The stages carried out in this research start from collecting data, carrying out initial processing, predicting certificate productivity, and carrying out accuracy testing and implementation[7].

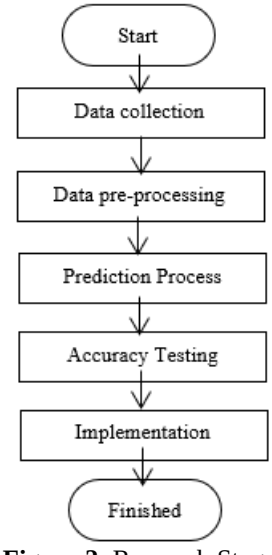

Figure 2: Research Stages

2.1 Data Collection

The data needed to carry out this research is in the form of productivity data from competency certificates for electrical

engineering personnel at an LSK. Data obtained from the PT Certification Manager's Annual Performance ReportEleska Iatkiwhich is generally used as a report for Internal Audit, External Audit, Company Budget Work Plan (RKAP), and DJK Annual Performance Report. The productivity data taken is data on the total number of certificates from several types of certification implementation.

There are 5 types of certification implementation, namely:
1) New Test / New Certification
2) Extension
3) Adjustment
4) Vocational
5) Procerat

Based on the trend the majority of implementation numbers in batch units refer to only 3 types of Certification implementation, so the author uses new, extended, and adjusted Test implementation data as the determining variable or independent variable. And the number of certificates as the target variable or dependent variable. The 2 types of certificate implementation are not used as determining variables because their implementation is very minimal in a certain period. In this research, the independent variable data unit is the implementation batch and the dependent variable is in certificate sheets.

2.2 Data Pre-processing

Preprocessing data is a technique used to convert raw data into a useful and efficient format[9]. Data preprocessing is carried out to produce data that is of good quality and ready to be used for the next stage[4].

The data preprocessing steps in this research are[10]:
1) Select raw data by sorting out what data will be used as variables that influence the predicted results of the number of certificate productivity. Data is normalized by carrying out data transformation according to the activation function used. This stage is to ensure that the data has no missing values.
2) Integrating or combining several data in a data set. In this case, the data to be processed must be ensured to have the same format.
3) Deleting or reducing data (cleaning data/cleansing data) that is not needed in the process of calculating the predicted number of certificate productivity, so that it can be calculated and processed using an algorithmic method.

At this stage, data on the number of tests carried out, data on the number of extensions carried out, and data on the number of adjustments carried out totaling 60 data are then grouped into 2 (two) types of data, namely 75% training data and 25% test data. Training data and testing data will be used in the prediction process. In this research, the activation function used is the Relu function.

2.3 Process for Predicting the Number of Certificate Productivity

Process predictions number of certificate productivity using the Artificial Neural Network (ANN) Backpropagation method in the following order[7]:

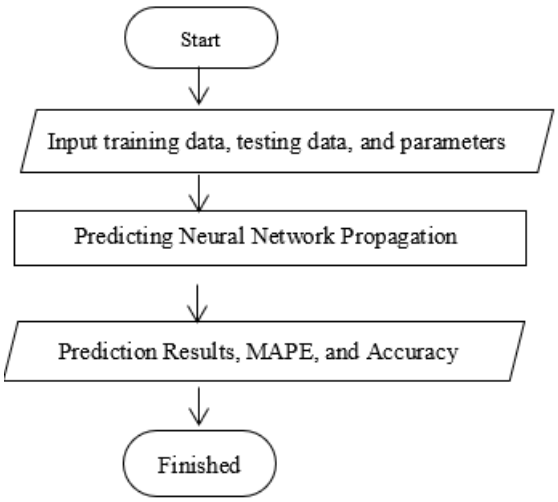

Figure 3: Flowchart of Predicting Number of Certificate Productivity with Backpropagation Neural Network

Predict the number of certificate productivity using ANN Backpropagation, starting by inputting training data and testing data. The input variables consist of the number of competency tests in batch units and the number of certificate extensions in batch units from 2018 to 2022. The resulting output is a prediction of the number of certificate productivity in 2023.

The next step is to determine the architecture of the ANN Backpropagation, starting by determining the number of parameters that will be used, such as hidden layers, epochs, and learning rate. After that, calculate the error and evaluate it using the MAPE method to obtain the level of accuracy and prediction[7].

2.4 Accuracy and Error Testing Process

MAPE is used in this research to evaluate the performance of various types of prediction models. The smaller the MAPE, the better the prediction model[7][11].

Table 2: MAPE Scale Criteria

MAPE Scale	Criteria
<10%	Very good
10%-20%	Good
20%-50%	Enough
>50%	Bad

3. Results

3.1 Data Collection

The data used in this research is data on the number of Certification implementations in batches over 5 (5) years, namely from 2018 to 2022. Certificate data is collected based on:
1) Number of Test Implementations per month in batch units

2) Number of Extension Implementations per month in batch units
3) Number of Adjustments Implemented per month in batch units

Data can be seen as follows:

Table 3: Number of Certificates for 2018-2022

Month	X1	X2	X3	Y
2018				
January	30	10	2	960
February	40	12	15	1119
March	45	15	20	1587
April	50	18	21	1668
May	51	45	100	2475
June	14	20	9	534
July	16	25	15	804
August	15	22	11	530
September	18	25	14	653
October	27	34	8	1057
November	32	16	7	847
December	30	15	5	844
2019				
January	20	22	12	1373
February	21	22	6	945
March	25	30	14	1035
April	30	46	21	1296
May	20	31	19	903
June	21	16	6	762
July	40	23	12	1168
August	41	16	18	1089
September	34	17	7	854
October	50	20	22	1622
November	57	12	12	1359
December	36	29	13	1228
2020				
January	11	27	5	610
February	14	25	11	657
March	16	35	4	806
April	0	27	5	528
May	8	16	2	318
June	28	15	0	720
July	21	19	12	898
August	30	6	3	638
September	41	20	13	1284
October	38	19	10	1146
November	33	14	12	978
December	40	13	14	1039
2021				
January	9	39	2	1109
February	14	35	1	944
March	39	32	1	828
April	32	35	1	957
May	26	23	3	407
June	26	26	9	562
July	17	14	7	762
August	19	8	19	822
September	25	6	32	1194
October	20	8	41	915
November	25	23	60	535
December	20	36	48	1037
2022				
January	17	12	34	535
February	13	17	60	1037
March	19	11	69	836
April	12	8	59	592
May	27	10	50	885
June	34	11	51	1129
July	33	1	48	733
August	27	1	60	994
September	18	2	55	771
October	40	1	53	1282
November	54	7	71	1423
December	21	2	52	813

X1 = Number of Tests (batch)
X2 = Number of Renewals (batch)
X3 = Number of Adjustments (batch)
Y = Number of Certificates (sheets)

3.2 Pre-Processing

In the preprocessing stage, the data that has been collected is then processed using data cleaning, which removes missing values so that there are no empty attributes. After cleaning the data, the next step is to normalize the data into values that are consistent with the range (0.1). Normalization is carried out using the MinMax method [4].

The module used for normalization is MinMaxScaller. Where variable.

Table 4: Data Normalization Results

Month	X1	X2	X3	Y
2018				
January	0.5263	0.2000	0.0200	0.2976
February	0.7018	0.2444	0.1500	0.3713
March	0.7895	0.3111	0.2000	0.5883
April	0.8772	0.3778	0.2100	0.6259
May	0.8947	0.9778	1,0000	1,0000
June	0.2456	0.4222	0.0900	0.1001
July	0.2807	0.5333	0.1500	0.2253
August	0.2632	0.4667	0.1100	0.0983
September	0.3158	0.5333	0.1400	0.1553
October	0.4737	0.7333	0.0800	0.3426
November	0.5614	0.3333	0.0700	0.2452
December	0.5263	0.3111	0.0500	0.2439
2019				
January	0.3509	0.4667	0.1200	0.4891
February	0.3684	0.4667	0.0600	0.2907
March	0.4386	0.6444	0.1400	0.3324
April	0.5263	1,0000	0.2100	0.4534
May	0.3509	0.6667	0.1900	0.2712
June	0.3684	0.3333	0.0600	0.2058
July	0.7018	0.4889	0.1200	0.3941
August	0.7193	0.3333	0.1800	0.3574
September	0.5965	0.3556	0.0700	0.2485
October	0.8772	0.4222	0.2200	0.6045
November	1,0000	0.2444	0.1200	0.4826
December	0.6316	0.6222	0.1300	0.4219
2020				
January	0.1930	0.5778	0.0500	0.1354
February	0.2456	0.5333	0.1100	0.1572
March	0.2807	0.7556	0.0400	0.2262
April	0.0000	0.5778	0.0500	0.0974
May	0.1404	0.3333	0.0200	0.0000
June	0.4912	0.3111	0.0000	0.1864
July	0.3684	0.4000	0.1200	0.2689
August	0.5263	0.1111	0.0300	0.1484
September	0.7193	0.4222	0.1300	0.4478
October	0.6667	0.4000	0.1000	0.3839
November	0.5789	0.2889	0.1200	0.3060
December	0.7018	0.2667	0.1400	0.3343

Month	X1	X2	X3	Y
2021				
January	0.1579	0.8444	0.0200	0.3667
February	0.2456	0.7556	0.0100	0.3408
March	0.6842	0.6889	0.0100	0.3204
April	0.5614	0.7556	0.0100	0.2902
May	0.4561	0.4889	0.0300	0.2364
June	0.4561	0.5556	0.0900	0.2962
July	0.2982	0.2889	0.0700	0.0413
August	0.3333	0.1556	0.1900	0.1131
September	0.4386	0.1111	0.3200	0.2058
October	0.3509	0.1556	0.4100	0.2337
November	0.4386	0.4889	0.6000	0.4061
December	0.3509	0.7778	0.4800	0.2768
2022				
January	0.2982	0.2444	0.3400	0.1006
February	0.2281	0.3556	0.6000	0.3333
March	0.3333	0.2222	0.6900	0.2401
April	0.2105	0.1556	0.5900	0.1270
May	0.4737	0.2000	0.5000	0.2629
June	0.5965	0.2222	0.5100	0.3760
July	0.5789	0.0000	0.4800	0.1924
August	0.4737	0.0000	0.6000	0.3134
September	0.3158	0.0222	0.5500	0.2100
October	0.7018	0.0000	0.5300	0.4469
November	0.9474	0.1333	0.7100	0.5123
December	0.3684	0.0222	0.5200	0.2295

X1 = Normalized number of tests
X2 = Normalized number of extensions
X3 = Normalized Adjustment Amount
Y = Normalized number of certificates

3.3 Data Sharing

Data on the number of certificates from 2018 to 2022 is 60 data, then divided into training data and test data. 75% of the training data is 45 data for each variable and 25% of the testing data is 15 data for each variable.

3.4 Architectural Model Design

This research uses an Artificial Neural Network Backpropagation architectural model which consists of several layers, namely the input layer, hidden layer, and output layer. In the input layer, there are 3 neurons which are the determining factor in the number of certificates. In the Hidden layer, there are 9 neurons obtained from the results of trial and error. Then in the Output layer, there is 1 layer that shows the predicted results of the number of certificates produced. Details of the design of the ANN Backpropagation architectural model in the process of predicting the number of competency certificates are as follows:

Table 5: ANN Backpropagation design table

Parameter	Amount	Information
Input layers	3 Neurons	Number of Test Batches Renewal Batch Number Number of Adjustment Batches
Hidden Layers	*trial and error*	9 Neurons
Output Layer	1 Neuron	Number of Certificates
Initial Weight	*trial and error*	Lower Limit: 0.05 Upper Limit: 0.08 Random Number between 0.05-0.08
Learning Rate	*Adam*	0.01
Momentum	*trial and error*	0.5-0.9
Epoch	*trial and error*	100
Activation Function	1	*Relu*

From the table above, the architecture can be described as follows:

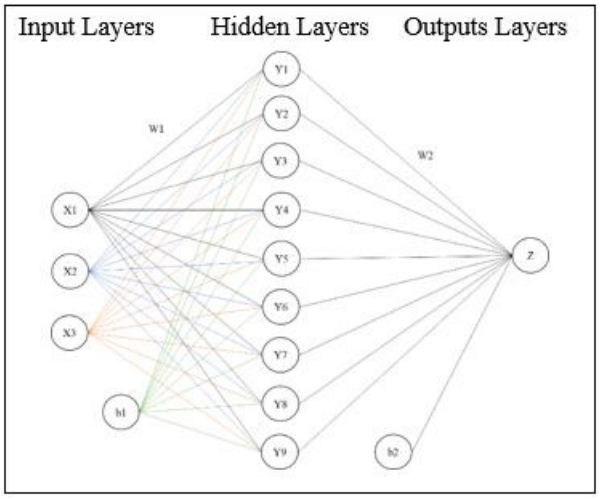

Figure 4: ANN architecture for predicting the number of certificates

The ANN architecture designed uses three neurons in the input layer, namely the number of test batches, the number of extension batches, and the number of adjustment batches. The hidden layer consists of 9 neurons. The weights used are in the range 0.05 to 0.08. The output layer is a prediction of the number of certificates with 1 neuron.

The learning rate parameter is useful for speeding up the iteration rate (epoch) [12]. The smaller the learning rate value, the greater the accuracy. This research was conducted with Adam's learning rate with a value of 0.01.

Iteration parameters (epoch) are a repetition parameter for termination in the training process. If the number of iterations has reached the maximum number then training will stop[7]. In this study, 100 epochs were used.

3.3 Prediction Process

Prediction accuracy will indicate system efficiency when evaluated against historical data to estimate measurement performance. The prediction accuracy is interpreted in Figure 5. The accuracy of predicting the number of certificates reached 91.3% with a Mean Absolute Percentage Error (MAPE) of 9.7%. Therefore, the proposed methodology will be effective.

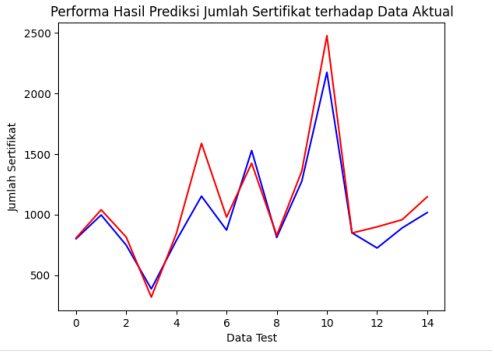

Figure 5: Visualization of Prediction Results on Actual Data

4. Conclusion

This research uses the Artificial Neural Network (ANN) method with the Backpropagation algorithm to predict the productivity of competency certificates for electricity engineering personnel at PT. Eleska Iatki based on the number of new tests, extensions, and adjustments (in batch units). The research results showed that the prediction accuracy reached 91.3% with a Mean Absolute Percentage Error (MAPE) of 9.7%.

This prediction method is expected to help company management in determining strategies for achieving goals in the future. For PT Eleska Iatki, it is hoped that this prediction method can be used to carry out a strategy in determining Certification targets for the coming year to achieve the highest amount of productivity to maintain the performance assessment from DJK. The proposed methodology is considered effective in predicting the number of competency certificates.

This study is significant as it provides a method for accurately predicting the productivity of competency certificates, which is crucial for strategic planning and maintaining high performance in the competitive field of electrical engineering certifications.

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