Hybrid Model of Seasonal ARIMA-ANN to Forecast Tourist Arrivals through Minangkabau International Airport

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Abstract. The number of tourist arrivals forecasting is required for the future development of tourism industry to improve the economic growth. The number tourist arrivals data can be analyzed by building a model so that it will help to find out the number of tourist arrivals in the next period which is through Minangkabau International Airport. The linear model that is used is Seasonal Autoregressive Integrated Moving Average (SARIMA) used and continued to build a nonlinear model of the residual SARIMA model using Artificial Neural Network (ANN). In this research, SARIMA model which obtained is SARIMA (1, 0, 1) $(1, 1, 0)^{12}$. But, residual of SARIMA model has not been fulfilled an autocorrelation assumption so that it isproposed a new model of SARIMA-ANN. The residual model of SARIMA is built using the ANN model architecture with 2–2–2–1 network topology. The performance rate of time series model of tourist arrivals which is the data started on January 2012 until March 2019 is measured using Mean Absolute Percentage Error (MAPE). Based on the MAPE value of 17.1770% indicates that the model obtained having good performance to forecast the number of tourist arrivals through Minangkabau International Airport in the future.

Keywords: neural network, mean absolute percentage error, seasonal autoregressive integrated moving average, tourist arrivals

1 Introduction

In certain seasons, sometimes there is an increase in the number of visitors to an area and usually occurs during the school holiday season, new year, Eid day, and other holidays. Therefore, this moment can be used to raise the standard of living of many locals, introduce nature and culture to improve economic growth of a nation. West Sumatera is one of the provinces in Indonesia that has many famous things from its culture and cuisine. One of the famous cultures is exquisite handicrafts which produce Songket and it used at traditional weddings. While, West Sumatera has one of the famous recipe dishes which by CNN Go calls as the world’s most favorite dish, which is the Rendang recipe. From the reasons, tourist arrivals have big impact in the future development industry of tourism to improve the economic growth. In order that, the forecasting of the number of tourist arrivals used to make plan the aircraft flights, facilities for traveling, tourism infrastructures, and much more. Furthermore, to solve the problem in the forecasting, statistical methods is alternative that can be used to build a model.

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In forecasting, there are unknown constant values which used to complete a model, namely parameters. Actually, linear models often used to estimate the parameters which play a role in forecasting a value in the future. But the reality is most of the model which is better than linear model in approaching actual value is nonlinear model. In forecasting the number of tourist arrivals, linear and nonlinear model which is used respectively are SARIMA and ANN. SARIMA used to be linear model because of the number of tourist arrivals through International Minangkabau Airport increase in the certain season.

Based on the previous researches on time series data model such as in the risk management as described in [1], GARCH is a model which used for forecasting volatility of stock prices which is used to compute values at risk in measuring financial risk. In forecasting time series model, many researches which used linear and linear model in the recent years. In financial case, to choose the optimal portfolio for stocks also can be modeled as explained in [2]. While the financial performance of Islamic Rural Banks can be applied by using clustering analysis as described in [3]. In other financial cases, time series of rainfall predicted by using Markov Autoregressive as in [4].

According to [5], the research is building a nonlinear model of Indonesia Composite Index using ANN with back propagation method. Based on the previous study in [6], the exchange rate was built a model using neural networks (NN). Combine methodology in time series using ARIMA and ANN conducted by [7] and [8]. They compare both models to know the best one. According to [9], they combined two model such as NN and ARIMA to get results with reduced errors.

Seasonal ARIMA in time series as explained in [10] and [11], they propose building a model of seasonal ARIMA model of tourism in Sri Lanka and Chile. The study in [10], they used some methods to compare the perfomance of the methods. They are Box Jenkins, the method of reducing the error of the forecasting result and the regARIMA method. While, according to [11], the seasonality of the data can be identified using the HEGY test. Then, the forecasting accuracy measured by using three criterions such as Mean Absolute Percentage Error, The Root Mean Squared Error, and Mean Absolute Error.

In other case, to combine methodology in time series also explained in [12] and [13] which use SARIMA and NN to forecast the Turkish market and the monthly income in West Iran. According to [12], ANN model were used to know the effect of some factors on the electrical loads. While, according to [13], in predicting the peak flood flows used hybrid model is better than the certain model. Then, in forecasting the electricity generation of Photovoltaic plants as described in [14], they compare four practical methods, namely SARIMA, SARIMAX, modified SARIMA, and ANN-based modeling.

Therefore, this study is purposed to build the hybrid model of SARIMA and NN. Therefore, it can be used to forecast the number of tourist arrivals through Minangkabau International Airport in the future.

2 Methods

2.1 Seasonal Autoregressive Integrated Moving Average

Forecasting is the processing to estimate a value in the future using analysis of the trends based on the data which have been exist. Forecasting used to reduce the risk that will be obtained by doing a long-term business by making a forecasting model. In building a model of time series data $\{Xt\}$, the data have to be stationary. The processing of stationary needed to make the mean, variance and autocorrelation stucture do not change over time. If time series is nonstationary, it desires to be minimized to stationary using power transformation and differencing as explained in [15]. The differencing with order d is divided into two, namely non-seasonal and seasonal differencing. The non-seasonal difference aimed to overcome data instability by removing trend elements in the data [16]. In general, the d-order differencing equation for X_t is:

$$\nabla^d X_t = (1-B)^d X_t \tag{1}$$

While seasonal difference used to remove seasonal elements in the data [17]. The D-order differencing equation for X_t is:

$$\nabla_s^D X_t = (1-B^S)^D X_t \tag{2}$$

The transformation of Box – Cox is one of the methods which used to make the data to be stationary that is not stationary in variance. Let $T(X_t)$ is transformation function of X_t. The following formula as explained in [17]used to stabilize the variance.

$$T(X_t) = \frac{X_t^\rho - 1}{\rho} \tag{3}$$

for $\rho \neq 0$ and ρ called transformation parameter.

The stationary checking can be tested using plotting data and Augmented Dickey-Fuller (ADF) testing as described in [18]. In this graph analysis, if the data have a constant and constant variance, the data is concluded to be stationary. While, the ADF test is used to test the stationary of the middle value in the time series data. The Dickey-Fuller equation for the differenced-lag model that is regressed is:

$$\nabla X_t = \mu + \delta X_{t-1} + \sum_{i=1}^{k} \phi_i \nabla X_{t-i} + e_t \tag{4}$$

for $\nabla X_t = X_t - X_{t-1}$ and k is the number of lags. The test statistical which is used as follows as:

$$ADF = \frac{\delta}{SE(\delta)} \tag{5}$$

The initial hypothesis is δ = 0, which means the data is not stationary and the criteria for decision making reject the initial hypothesis if the ADF value is less than the test statistics in the table.

A process of time series $\{X_t\}$ is called white noise if there are not correlation random inter variables from a fixed distribution with a constant mean is equals to 0 and constant variance $Var(X_t) = \sigma^2$ and $Cov(X_{t+h}, X_t) = 0$ for $k \neq 0$[17]. In time series analysis, there are some time series models such as Seasonal Autoregressive Integrated Moving Average (SARIMA) which is a famous model to predict the seasonal time series which can be expressed as the following formula.

$$\phi^*{}_P(B^S)\phi_p(B)(1-B)^d(1-B^S)^D X_t = \theta_q(B)\theta_q{}^*(B^S)\varepsilon_t \quad (6)$$

where p, d, q, P, D, Q are integers, s is the season length, non-seasonal difference equation is

$$\phi_p(B)(1-B)^d X_t = \theta_q(B)\varepsilon_t \quad (7)$$

and the seasonal difference equation is

$$\phi^*{}_P(B^S)(1-B^S)^D X_t = \theta_q{}^*(B^S)\varepsilon_t \quad (8)$$

In fitting a SARIMA model, first determine the order of the SARIMA model, estimating unknown parameters and collect model candidates which have a p-value of less than 0.05, testing the goodness of fit on the predicted errors and then forecast a value in the future using the data which are exist. To build SARIMA model, the autocorrelation and partial autocorrelation function charts are needed to determine the order of the SARIMA model. If the candidate model has been selected then the best model selection is done based on the AIC and BC values [17]. Systematically the equations of AIC and SC can be written respectively as the following:

$$AIC = n \quad \ln(SSE) + 2k \quad (9)$$

$$SC = n \quad \ln(SSE) + k \quad \ln(n) \quad (10)$$

where SSE is sum of squared errors, k is the number of parameters which will be estimated, and n is the number of observation. The best model selection can be determined by using the model which has a smaller value of AIC and SC than the other candidate models. After fitting the models as in [18], SARIMA model has to be diagnosed the linear relationship independency using the formula as follow as:

$$Q_{LB} = n(n+2)\sum_{k=1}^{K}\left(\frac{r_k^2}{n-k}\right) \quad (11)$$

The number of observation data is denoted as n, r_k^2 is sample autocorrelation coefficient at lag k = 1,2,3, …, K and K is lag length. The SARIMA residual is non-autocorrelation if $Q_{LB} > \chi_\alpha{}^2(K-p-q)$. In normality test, Jarque Berra (JB) used to diagnose SARIMA residual whether or not they are normally distributed. Statistics test of JB is [19]:

$$JB = \frac{n}{6}(S^2 + \frac{(K-3)^2}{4} \quad (12)$$

where K is kurtosis and S is skewness. SARIMA residual will have normally distributed if $JB \le \chi_\alpha{}^2(2)$.

2.2 Artificial Neural Network

In the case of forecasting, neural netwok is used to help forecasting a value in the future using numerical methods. Neural networks in artificial intelligence was found by McCulloch and Pitts in 1943. They presented a model of mathematics of the neuron as the basic element of the brain. The idea make the innovation for building the construction of the networks as explained in [20]. A simple mathematical model of the neuron will be shown in the **Figure 1**.

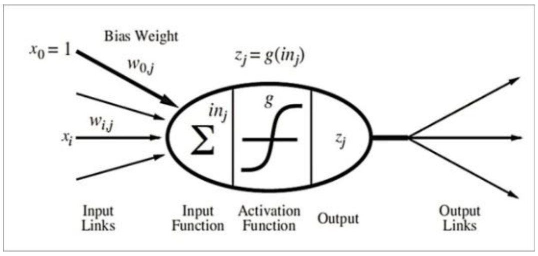

Fig. 1. A mathematical model for a neuron

Based on **Figure 1**, the networks consist of nodes which connected by directed links. The link from unit i to j provides for spreading the input data x_i from i to j. To determine the sign and strength of the connection between two nodes, they need a weight w_{ij} associated with it. Each unit j first counts a weighted sum of its inputs:

$$in_j = \sum_{i=0}^{n} x_i w_{ij} \tag{13}$$

Then the function of g is applied to the fomula (13) to obtain the output $z_j = g(in_j) = g(\sum_{i=0}^{n} x_i w_{ij})$ and continued to other neurons as a new set of input data.

According to [21], there are two distinct ways to make the network after deciding on the mathematical model of a neuron. They are feed-forward and recurrent network. In the feed forward networks, each unit accepts the input only from units in the directly previous layer. In single layer networks, each unit connects directly from input to output layer. While on a multilayer network, there are one or more layers of the hidden units that are not connected to the outputs of the network. In the recurrent network, feed the outputs back to its own input. It means that the level of network activation form may approach a stable state or show the chaotic behavior. But, recurrent networks can used if the problem which is only supporting the short term memory in order that it makes this network is more difficult to be understood.

The activation function used to transform the data to be the new data associated with the result of the activation function that will be used. There are three functions provided which is explained in [22]: sigmoid, hyperbolic tangent, and linear. The sigmoid, hyperbolic tangent, and linear function can be expressed as respectively in the following formula.

$$f(x) = \frac{1}{1 + \exp(-x)} \tag{14}$$

$$f(x) = \frac{\exp(2x) - 1}{\exp(2x) + 1} \tag{15}$$

$$f(x) = x \tag{16}$$

The result of each function are different. It depends on the data which will be used. The sigmoid function has a value between 0 and 1 or it only returns positive values. If the network needed to return negative numbers, the sigmoid function will be unsuitable. The activation function that can be used to solve that problem is a hyperbolic tangent function because the function returns both positive and negative values. While the linear function does not transform the old data. The function used in the conditions if the entire range of the numbers to be output needed such as boolean operation. The function can be delivered from the mathematical transformation. According to [23], [24], [25] and [26], there are characterizing property transformation of for certain which a unique form.

According to [22], there are two steps to construct a model of the artificial neural network. They are training and validation neural network. In training neural network, each weight associated in the directed links are processed until the errors between observation and network output are smaller than a pre-specified threshold value which is usually a smallest value as in [27]. The network training also depends some methods that will be purposed such as supervised, unsupervised, and hybrid approaches. The algorithm in learning the data in the networks is usually using back propagation because it uses the gradient descent to reduce the errors in the netwoks as in [22]. The algoritm consists of the following steps. First, the weights of the network have to be initialized randomly. Second, the feed forward network process the information of the data through each network using the activation function until it gets the new information. Third, asses the error which is obtained by the network. If the error is lower than the pre-specified threshold value, the algorithm of the network can be terminated. Fourth, compute the gradient of the change in error and then propagate the error used to modify each weight in the layers. Fifth, the change in error of the weight used to adjust the old weights in order that the error can be reduced. It will be repeated until the criterion of the threshold value is fulfilled.

In building a model, there are two measures of model accuracy in the forecasting which are the most frequently used. First, Mean Square Error or MSE. Mean Square Error (MSE) is a measure used to measure the average error of a model. MSE can be formulated as follows:

$$MSE = \frac{SSE}{N} = \frac{\sum_{i=1}^{N} (t_i - y_i)^2}{N} \tag{17}$$

Second, MAPE used to measure the accuracy of the model using certain forecasting methods in a given data set. The MAPE value can be formulated as follow as:

$$MAPE = \frac{1}{N} \sum_{i=1}^{N} \frac{| t_i - y_i |^2}{t_i} \times 100\% \tag{18}$$

where SSE is sum square error, N is the number of data observation, y_i is the observed or actual output data, and t_i is the target output using a particular method as in [15].

3 Results and Discussion

Before building a model of Seasonal Autoregressive Integrated Moving Average (SARIMA), firstly we have to know how fluctuation of the data which will be used. The plotting of the number of arrivals of the foreign tourist through the Minangkabau International Airport can be shown by **Figure 2**.

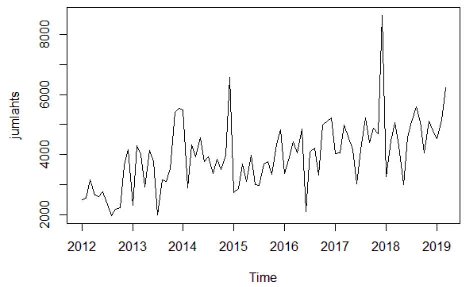

Fig. 2. The number of tourist arrivals through the Minangkabau International Airport

Based on **Figure 2**, the plotting data shows that it slightly has trend. Although it shows that the mean of data is almost stationary. It has to perform ADF test for stationary, the p-value of ADF test is 0.01 less than 0.05, which means that the mean of the data is stationary. But, the variance of the data seems to change over time, so that the data are slightly suspected to be stationary against the variance. In other that, Box Cox transformation is purposed to make the variance of the data to be stationary. The result of Box-Cox transformation gives the parameters value of λ is 0.2935415 and 1. It means that the data will be transformed once in order to get the new data.

After the data are already stationary, then the order p, q, P, and Q of the model can be obtained by using plot of ACF and PACF. The following figure shows ACF and PACF chart for SARIMA model.

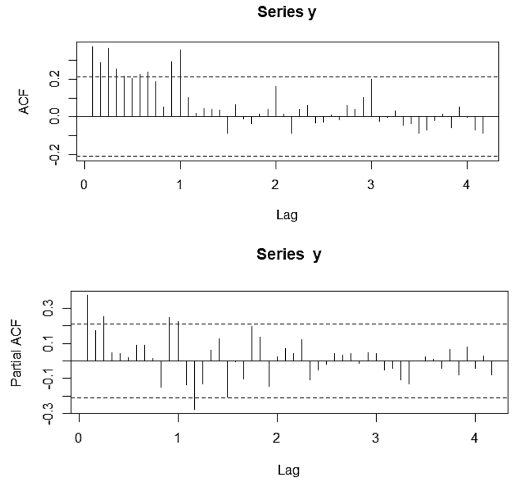

Fig.3. ACF and PACF chart for SARIMA model

Based on **Figure 3**, ACF chart shows that the cut-off data after lag 4 and it is assumed to be the order of MA (q=4) and PACF chart shows that the cut-off data after lag 1 so AR order is suspected (p = 1). Because the data is stationary, it is assumed that the initial model formed with d = 0 is the ARIMA model (1,0,4). In the PACF chart, it can be seen that the data still contains seasonal, because it is significant in lag 12, 24 and 36. For this reason, it is necessary to do seasonal differencing process to eliminate seasonality with period S = 12. The following charts show a chart of ACF and PACF with seasonal differencing.

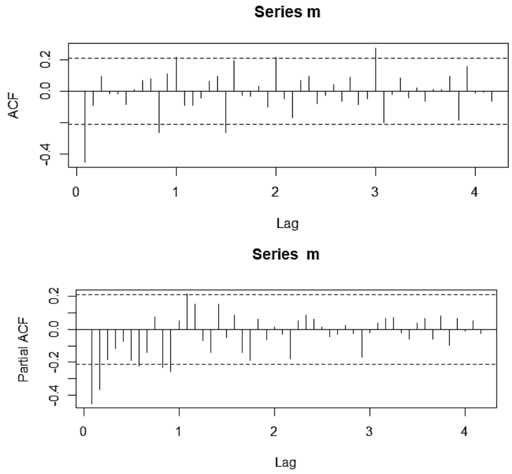

Fig. 4. ACF and PACF chart with seasonal differencing.

From **Figure 4**, it shows that ACF chart is significant in lag 1 (Q=1) and PACF chart in lag 2 (P=2). In other that, the initial conjecture model formed is the ARIMA model (2,1,1). After doing the estimation of parameters model in some possible models using combination of the order of the model, obtained that the parameters model which have p-value is lower than 0.05 is SARIMA (1,0,1)(1,1,0)12. The last step that has to do is regression assumptions of normality, homoschedasticity, and autocorrelation testing. The following table shows that the p-value for regression assumption.

Table 1. Regression Assumption.

Model	Normality	Homoschedasticity	Autocorrelation
SARIMA $(1,0,1)(1,1,0)^{12}$	0.06598	0.8247	p-value is lower than 0.05 after lag 12

Based on Table 1, p-values of regression assumption of SARIMA $(1,0,1)(1,1,0)^{12}$ which have been fulfilled are normality and homoscedasticity test. In autocorrelation test, there are p-value that is still lower than 0.05. It means that SARIMA $(1,0,1)(1,1,0)^{12}$ model improper use to forecast the number of tourist arrivals through Minangkabau Airport. The alternative which used to resolve the problem is building a residual model of SARIMA using ANN which is no regression assumption.

In determining the ANN model, first, the input and output data determined. Input data which will be used are the number of tourist arrivals through Minangkabau Airport are the t-1 and t-2 data. While target data which want to be obtained is the t-data. The second step is normalization of data. All of sample data have to transform into a value between 0 and 1 because activation function which used in artificial neural network is sigmoid function. Then, architecture of the artificial neural network will be constructed to know how many units for each layer. Based on the data, the architecture of the artificial neural network, which used is 2-2-2-1. It means that the network consists of two input units, two hidden units in the first and second layer, and one output unit. The architecture of the artificial neural network will be shown in **Figure 5.**

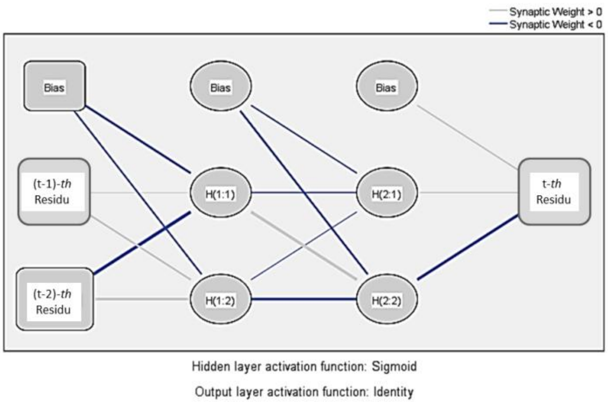

Fig.5. The construction of neural network

The next step is training neural networks. Learning algorithms of the artificial neural network consist of initialization, feed-forward, error assessment, propagation, and adjustment.In the initialization of the network, a neural network is generally initialized with random weights. Based on Fig.5, initial values of the synaptic weights for the bold line is lower than 0. Otherwise, initial values are greater than 0. In the training process, the network has 52 data, learning rate (η) is 0.01, activation function which used is sigmoid function, and error assessment of 0.001 as a threshold value so far algorithm can be stopped. In feed forward, each input unit (x_{ki} ,i=1,2,…,5) accepts input data and distribute the data into each hidden unit. Then, in the error assessment, if $|t_{k1} - o_{k1}| > 0.001$ for k=1th data, stopping criterion is not available, thus the training of the network has not finished. In back propagation, the correction value of weights and bias are used to make the error are lower than 0.001. in other that, the new weight will be obtained in the adjustment process. From feed forward until adjustment process will be repeated if the error has not obtained lower than 0.01.

The fifth step is validation neural network. Validation process, the data which used to test a network is 33 data. The following table is a model summary of training and testing process.

Table 2. Model Summary

Model	Normality	Homoschedaticity
Mean Squared Error (MSE)	0.489656277	0.315305573

Based on Table 2, it shows that MSE value of training is greater than testing. It means that the network has the ability to recognize new data. Finally, a model which obtained can be purposed to forecast the number of tourist arrivals through Minangkabau Airport. The last step is model residuals of SARIMA model. After learning algorithms have finished, obtained new weights which will be used to make a nonlinear model of residual of SARIMA. Parameter estimation can be shown in Table 3.

Table 3. Parameter Estimates

Parameter Estimates						
		Predicted				
Predictor		Hidden Layer 1		Hidden Layer 2		Output Layer
		H(1:1)	*H(1:2)*	*H(2:1)*	*H(2:2)*	*X(t)*
Input Layer	(Bias)	-0.418	-0.373			
	X(t-1)	0.009	0.408			
	X(t-2)	-0.677	0.549			
Hidden Layer 1	(Bias)			-0.113	-0.418	
	H(1:1)			-0.068	0.675	
	H(1:2)			-0.042	-0.437	
Hidden Layer 2	(Bias)					0.244
	H(2:1)					0.048
	H(2:2)					-0.653

Based on Table 3, residual model of SARIMA using ANN with back propagation method can be written to be:

$$y_{k1} = \frac{1}{1 + \exp\left(-(0.244 + 0.048 H(2:1) - 0.653\, H(2:2))\right)}$$

where

$$H(2:1) = \frac{1}{1 + \exp(-(-0.113 - 0.068 H(1:1) - 0.042 H(1:2))}$$

$$H(2:2) = \frac{1}{1 + \exp(-(-0.418 + 0.675 H(1:1) - 0.437 H(1:2))}$$

$$H(1:1) = \frac{1}{1 + \exp(-(-0.418 + 0.009 x_{ki} - 0.677 x_{k2}))}$$

$$H(1:2) = \frac{1}{1 + \exp(-(-0.373 + 0.408 x_{ki} + 0.549 x_{k2})}$$

for $y_{k1}$is kth actual output which has been normalized, $x_{k1}, x_{k2}$are kth input data which have been normalized.

Based on the equation (18), the MAPE value of SARIMA is 17.17702 % and the MAPE value of hybrid model SARIMA and ANN is 17.0963%. The MAPE value will be used to show the performance of the model. Based on the MAPE value, it shows that hybrid model of SARIMA-ANN has a better performance than SARIMA model. Furthermore, the forecasting value of the number arrivals touristis almost approaching the real value. It helps the government and the investors to know how the fluctuation of arrivals tourist is. In other side, the risks that will be assumed is getting smaller.

4 Conclusion

Seasonal Autoregressive Integrated Moving Average (SARIMA) is one of statistical methods in time series data with a sesonal component. Although there are regression assumption that has been fulfilled to make the model is available used to forecast a value in the future, it can be resolved using Artificial Neural Network (ANN). Residual model of SARIMA using ANN makes the error which is obtained become smaller. It shows that ANN can be used to resolve the regression assumption that has not been fulfilled.

Based on the data using hybrid model of SARIMA and ANN, after forecasting the number of tourist arrivals in Minangkabau Airport, the MAPE value of the network is 17,0963%. This value is less than the MAPE value of 17.17702 before ANN model combined with SARIMA. It means that the model of hybrid model of SARIMA and ANN that have been obtained having a good performance to forecast the number of tourist arrivals in Minangkabau Airport in the future.

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