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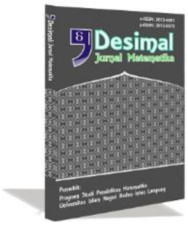

Backpropagation algorithm modeling to predict the number of foreign tourist visits to indonesia via air gates

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ABSTRACT

The tourism sector is a supporting sector for the Indonesian economy. One of the important actors in Indonesian tourism is foreign tourists. After the COVID-19 pandemic, the trend of foreign tourist visits to Indonesia has increased. The Central Statistics Agency (BPS) recorded that foreign tourist visits to Indonesia during 2022 reached 5.47 million. This figure has increased by 251.28% compared to the 2021 period. According to BPS, one of the gates most accessed by foreign tourists is the air gate. Based on these conditions, this research aims to predict the number of foreign tourists coming to Indonesia via air gates. The method used to predict is the backpropagation algorithm. The use of the backpropagation algorithm is able to provide prediction results with the highest level of accuracy of 91.40% for tourist visits at Ngurah Rai Airport, Bali. Furthermore, an MSE value of 0.056 was obtained. Thus, predictions using the backpropagation algorithm can be said to be good and quite accurate and can be used for prediction calculations in the following year.

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INTRODUCTION

Tourism is an important economic sector in Indonesia because it has a strategic position to increase the country's foreign exchange. The Organization for Economic Co-Operation and Development (OECD) stated in its 2022 Tourism Trends and Policies report that in 2019, the tourism sector contributed 5.0% of Indonesia's Gross Domestic Income (GDP) (OECD, 2022). However, the impact of the COVID-19 pandemic in 2020 resulted in a decline in tourism's contribution to GDP by 56%, namely to only 2.2% of the total economy. In 2023, the recovery of the tourism sector and the creative economy will be even stronger after the pandemic, although they have not yet reached pre-pandemic levels. The Central Statistics Agency (BPS) recorded that foreign tourist visits in the first quarter of 2023 cumulatively reached 2.5 million visits, or an increase of 508.87% compared to the same period in 2022 (Badan Pusat Statistik Indonesia, 2022).

Factors driving the high interest of foreign tourists in Indonesia include Indonesia's many natural beauties, culture, and ancestral heritage that are still original. Apart from that, diverse culinary delights, relatively cheap and easily accessible transportation, as well as many national and international events, are also other supporting factors. There are several entrances that can be reached by foreign tourists. Based on data released from bps.go.id, it is known that the entrance most frequently accessed by tourists is the air gate. The Indonesian government itself has added air entrances in 2022 to a total of 10 points. Increasing the entrance for foreign arrivals will have the opportunity to increase the number of foreign tourists coming to Indonesia.

Considering that tourism is an important sector for the country, investment is needed in various aspects, including the development of international airport infrastructure, public transportation facilities, tourist attraction facilities, and various related facilities. This process takes a long time and costs a lot of money, so it requires the right strategy to get maximum results. Good planning is also needed to anticipate dynamic changes to avoid undesirable bad things, such as a decrease in the number of tourists to Indonesia. An effective way to anticipate this is to calculate future predictions. Therefore, this research was conducted to predict the number of foreign tourist visits to Indonesia via air gates in the future as material for formulating strategic policies for the tourism sector.

There are many methods developed to predict the number of tourists in the future. The method most widely used in making predictions is artificial neural networks (Koesriputranto, 2015), because this modeling is dynamic and real-time. Artificial Neural Networks have been widely used in various applications, including predictions in the tourism sector (Winanjaya & Okprana, 2023). One of the methods in Artificial Neural Networks used to make predictions is backpropagation (Budiharjo, Soemartono, Windarto, & Herawan, 2018; Siregar & Wanto, 2017). The use of the backpropagation algorithm is expected to be able to provide increasingly accurate results for predicting the number of foreign tourist arrivals to Indonesia so that it can become a reference for the government to improve various existing sectors.

The Backpropagation algorithm is a supervised learning method. Apart from that, backpropagation is also a lesson developed from Perceptron rules. Backpropagation has 3 stages that must be carried out in network training, namely the forward propagation stage, the backpropagation stage, and the weight and bias change stage. This network architecture consists of an input layer, a hidden layer, and an output layer. Apart from that, Backpropagation is also an ANN Multi-Layer Network, so that the lowest target error value can be obtained in an algorithm by looping between the prediction results. Backpropagation ANN is adaptive because it has the advantage of being able to adjust to the smallest errors in solving problems in the system

Research by Setti et al. (2019) was carried out to predict internet users around the world using the Backpropagation algorithm. The result is an accuracy rate of 92% with the 3-50-1 architectural model, and an MSE of 0.00151674 is obtained. Sari (2016) has conducted research to predict the rupiah exchange rate against the US dollar using Backpropagation Gradient Descent Time Series with Conjugate Gradient optimization. The research results show that the MSE value of the basic Backpropagation gradient descent algorithm is 1.02159, and the conjugate gradient produces an MSE of 0.0198012. Karmiani et al. (2019) concluded that Backpropagation is better than the SVM, LSTM, and Kalman methods with higher speed and accuracy. From the research results, Putri, Poningsih, & Tambunan (2021) concluded that the use of the Backpropagation method can be used to predict the number of foreign tourist visits where valid data is available. However, this research does not focus on looking at tourist entrances, especially air doors. In fact, the most accessible thing for tourists to Indonesia is the air gate. Therefore, this research focuses on applying the Backpropagation algorithm to predict the number of foreign tourist visits to Indonesia via air gates because it has never been done in previous research.

METHOD

Research Population and Sampling

The data source used in this research is secondary data. The population of this research is foreign tourists visiting Indonesia. The research sample consists of foreign tourist visits via air gates from 2017 to 2022, taken from the www.bps.go.id website (Badan Pusat Statistik Indonesia, 2022).

General Process

There are several steps for Backpropagation algorithm optimization analysis to predict the number of foreign tourist visits:

1. Collecting data from the Central Statistics Agency website.
2. Literature study to complete the basic knowledge and theories used in research.
3. Identifying problems for processing the conversion stage of the data obtained according to the specified weights.
4. Carrying out preprocessing with the aim of facilitating understanding of the Backpropagation algorithm process.
5. Determine network architecture patterns and models that are tailored to the research problem at hand.
6. Examining the results of data processing using computer applications.
7. Make predictions.
8. Final evaluation to find out whether the results of data processing are as desired.

Framework

Broadly speaking, the framework in this study can be described in Figure 1 (Setti et al., 2019).

Data Normalization

Normalization of the data is carried out so that the network output matches the activation function used. The initial data that has been collected will be normalized using a normalization formula, resulting in a value between 0 and 1. This is done in accordance with the normalization provisions in the following equation.

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

with $\boldsymbol{x'}$ is normalized data, $\boldsymbol{x}$ is initial data, $\boldsymbol{a}$ is the smallest initial data, and $\boldsymbol{b}$ is the largest initial data.

Backpropagation Algorithm

Backpropagation is a systematic method in ANN that uses a supervised learning algorithm and is usually used by perceptrons with many layers to change the weights connected to the neurons in the hidden layer. This algorithm is an ANN model that has the ability to strike a balance between the ability to recognize patterns and provide the correct response (Ilyas, Marisa, & Purnomo, 2018; Salimu & Yunus, 2020; M. Yanto, Mandala, Putri, & Yuhandri, 2018). According to Khusniyah & Sutikno (2016), the backpropagation algorithm is an easy and simple iterative algorithm that usually performs well, even with complex data. The backpropagation algorithm uses the output error to change the value of the weights in the backward direction. To get this error, the forward propagation stage must be carried out first. During forward propagation, neurons are activated using the sigmoid activation function, namely:

$$\boldsymbol{f(x) = \frac{1}{1 + e^{-x}}}$$

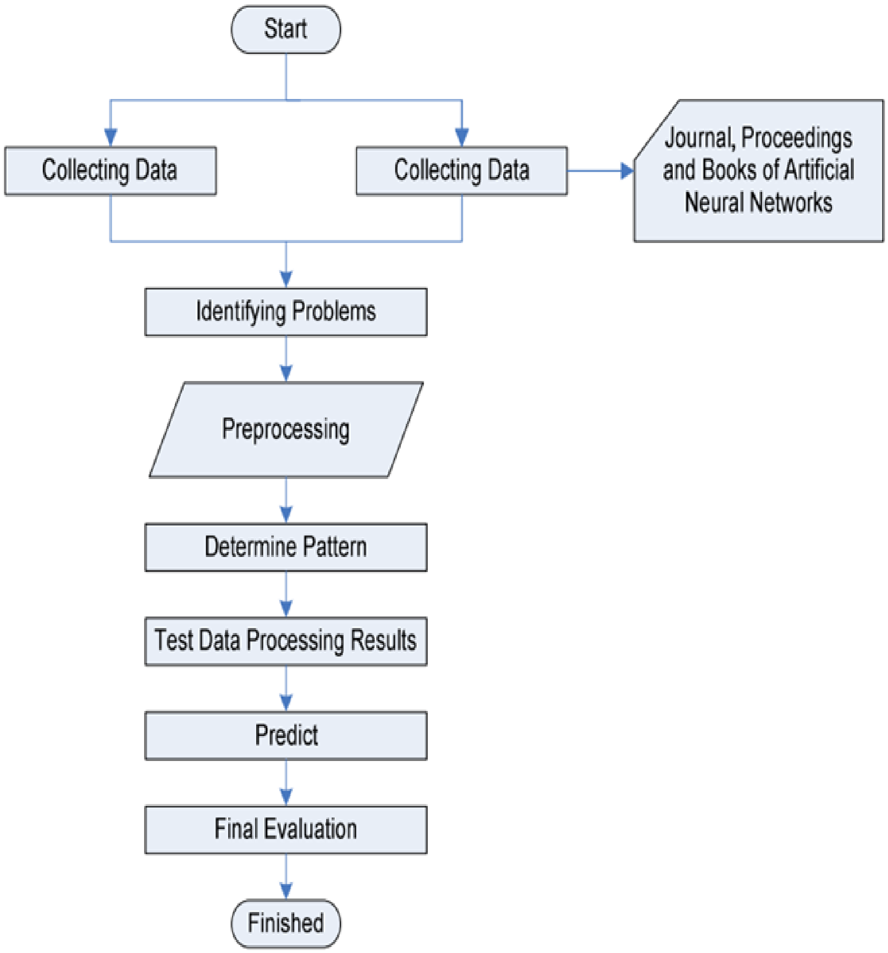

Figure 1. Framework

The backpropagation network architecture is as shown in Figure 2.

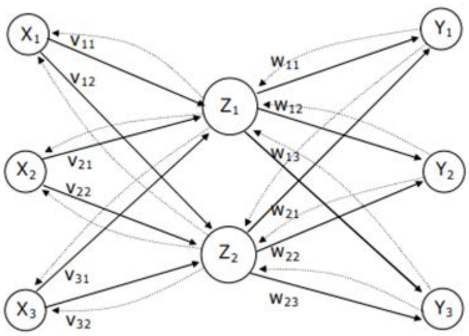

Figure 2. Backpropagation Network Architecture

Backpropagation Algorithm Stages

There are two types of calculations in this algorithm, namely:

1. Forward calculation to calculate the error between the actual and target output.
2. Backward calculation to backpropagate, the error is to correct the weights for all existing neurons.

The stages in the Backpropagation algorithm are given in Figure 3.

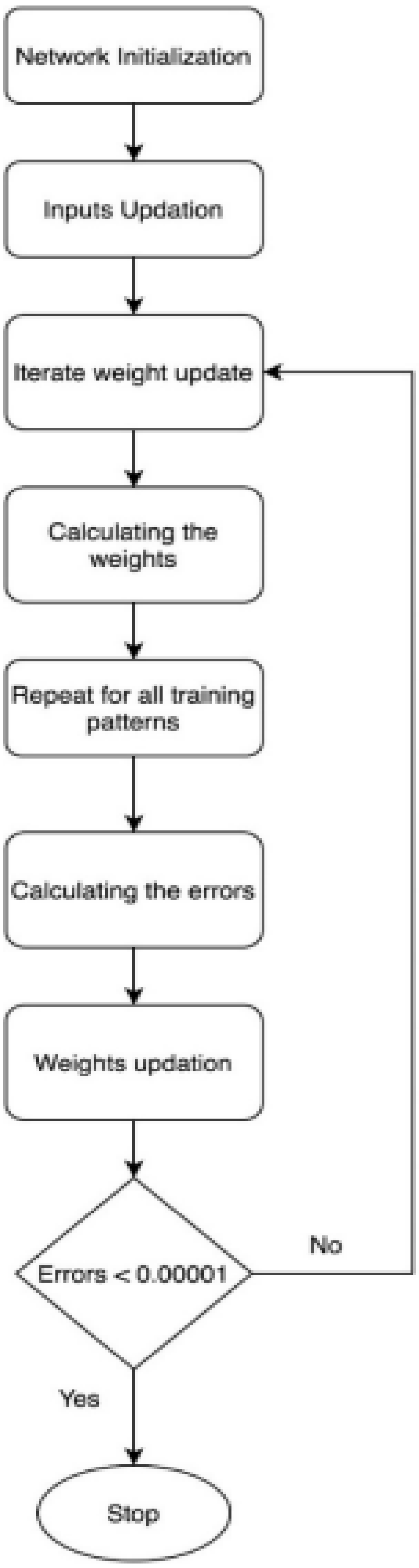

Figure 3. Flowchart of Backpropagation Algorithm

Source: (Kuninti & Rooban, 2021)

Step 0: Initialize weights and bias

Both weights and bias can be set to any number (random) and are usually numbers around 0 and 1 or -1 (positive or negative bias).

Step 1: If the stopping condition is still not met, then you must carry out steps 2–9.

Step 2: For each training dataset, steps 3–8 are carried out.

Feed forward

Step 3: Each input unit $(\boldsymbol{x_i}, \boldsymbol{i} = \boldsymbol{1}, \dots, \boldsymbol{n})$ receives an input signal $\boldsymbol{x_i}$ and spreads the signal to all units in the hidden layer. Please note that input $\boldsymbol{x_i}$ What is used here is input training data that has been scaled.

Step 4: Each hidden unit $(z_j, \boldsymbol{j} = \boldsymbol{1}, \dots, \boldsymbol{p})$ will add up the weighted input signals, including the bias,

$$z_{inj} = v_{0j} + \sum_{i=1}^{n} x_i \, in_{ij}$$

and uses a predetermined activation function to calculate the output signal from the hidden unit in question,

$$z_j = f(z_{inj})$$

then sends this output signal to all units in the output unit.

Step 5: Each unit of output $(\boldsymbol{y_k}, \boldsymbol{k} = \boldsymbol{1}, \dots, \boldsymbol{m})$ will add up the weighted input signals, including the bias,

$$y_{ink} = w_{0k} + \sum_{j=1}^{p} z_j \, w_{jk}$$

and uses a predetermined activation function to calculate the output signal from the output unit in question,

$$y_k = f(y_{ink})$$

Backpropagation of Error

Step 6: Each unit of output $(y_k, \boldsymbol{k} = \boldsymbol{1}, \dots, \boldsymbol{m})$ receives a target (expected output), which will be compared with the resulting output.

$$\delta_k = (t_k - y_k) \, f'\,(y_{ink})$$

Factor $\boldsymbol{\delta_k}$ used to calculate error correction (Δw_{jk}) which will later be used to update $\boldsymbol{In_{jk}}$, with

$$\Delta w_{jk} = a \delta_k z_j$$

Apart from that, bias correction is also calculated Δw_{0k} which will later be used to update w_0k, with

$$\Delta w_{0k} = a \delta_k$$

Factor $\boldsymbol{\delta_k}$ is then sent to the layer in front of it.

Step 7: Each hidden unit $(z_j, \boldsymbol{j} = \boldsymbol{1}, \dots, \boldsymbol{p})$ adds up the delta input (sent from the layer in step 6, which is already weighted.

$$\delta_{\boldsymbol{inj}} = \sum_{k=1}^{m} \delta_k \, w_{jk}$$

Then the result is multiplied by the derivative of the activation function used by the network to produce an error correction factor δ_j, with

$$\delta_j = \delta_{inj} \, f'(z_{inj})$$

Factor $\boldsymbol{\delta_j}$ is used to calculate error correction$(\Delta \boldsymbol{v_{ij}})$ which will later be used to update $\boldsymbol{v_{ij}}$, with

$$\Delta v_{ij} = a \delta_j \, x_i$$

Apart from that, bias correction is also calculated Δv_{0j} which will later be used to update Δv_{0j}, with

$$\Delta v_{0j} = a \delta_j$$

Weight and bias updates:

Step 8: Each unit of output $(y_k, k = 1, \dots, m)$ will update its bias and weights with each hidden unit.

$$w_{jk}(new) = w_{jk}(old) + \Delta w_{jk}$$

Likewise, each hidden unit will update its bias and weight with each input unit.

$$v_{ij}(new) = v_{ij}(old) + \Delta v_{ij}$$

Step 9: Check stopping conditions

If the stop condition has been met, then network training can be stopped.

Stopping Condition

To determine stopping conditions, there are two methods commonly used, namely:

a) Limit the iterations you want to do.

b) Limiting errors by determining the size of the Mean Square Error between the desired output and the output produced by the network.

Mean Square Error (MSE)

The error rate in the Backpropagation algorithm can be seen from the Mean Square Error (MSE) results. If there are m training data points, then to calculate the MSE, the following equation is used:

$$MSE = \sum_{i=1}^{n} \frac{(t - y_k)^2}{n}$$

where t is the actual value, y_k is the predictive value, k index for units of output, n is a lot of data.

RESULTS AND DISCUSSION

Data on foreign tourists visiting Indonesia via air terminals from 2017 to 2022 will be normalized first. The results of the normalization process are used for Artificial Neural Network training in Microsoft Excel and R software. After that, the initial weight initialization stage continues. This initial weight initialization is determined randomly with a relatively small value. For previously designed architectures, the initial weight that connects the input layer to the hidden layer is symbolized by *v = (v11, v12, v13, v14, v15, v21, v22, v23, v24, v25, v31, v32, v33, v34, v35, v41, v42, v43, v44, v51, v52, v53, v54, v55).*

Table 1. Initial Weight from the Input Layer to the Hidden Layer

Weight	*z1*	*z2*	*z3*	*z4*	*z5*
v1	-0.773	0.245	0.219	0.247	0.722
v2	0.281	-0.981	-0.535	0.332	0.029
v3	0.387	0.089	-0.435	0.847	-0.415
v4	0.675	-0.428	-0.466	-0.627	-0.536
v5	-0.367	-0.395	-0.682	-0.92	-0.562

Next, the weight that connects the hidden layer to the output layer is symbolized by *w = (w1, w2, w3, w4, w5).*

Table 2. Initial Weight from the Hidden Layer to the Output Layer

Weight	*Y*
w1	-0.856
w2	0.278
w3	-0.324
w4	0.249
w5	-0.848

The bias values given randomly from the input layer to the hidden layer are given in Table 3.

Table 3. Bias Value from the Input Layer to the Hidden Layer

Bias	*Vj*
1	-0.375
2	-0.697
3	0.438
4	0.196
5	0.863

Meanwhile, the bias value from the hidden layer to the output layer is given randomly, namely *wj = 0.68.*

Feedforward Level

In the feedforward stage, repetition is carried out until all hidden layer values are obtained. The next step calculates all output from the hidden layer *zj* with *j = 1, 2, ..., 5.* The result of adding weighted input signals, including the bias, is produced as follows:

$$z_{in1} = -0.474064$$
$$z_{in2} = -1.720855$$
$$z_{in3} = 0.602590$$
$$z_{in4} = -0.238988$$
$$z_{in5} = -0.672445$$

The results of calculating the output signal from the hidden unit in question using the binary sigmoid activation function are obtained as follows:

$$z1 = 0.384$$
$$z2 = 0.152$$
$$z3 = 0.646$$
$$z4 = 0.441$$
$$z5 = 0.338$$

The result of adding weighted input signals is symbolized by and_{ink}, which obtained a value of -0.398. In the next process, from the activation function that has been determined to calculate the output signal from the output unit, a value is obtained $and_k = 0.402$.

Backpropagation Stage

In this backpropagation stage, each output layer neuron receives a target output pattern related to the training input pattern and then passes it to the hidden layer until it reaches the input layer neuron. At the backpropagation stage, when the output target has not been met, adjustments are made to the bias and weights.

The initial step in the backpropagation stage is to calculate the expected output target, symbolized by δ_k with a result of 0.006. After that, proceed with calculating changes in weight $\Delta w_{jk} = a\delta_k z_j$ with α (learning rate) of 0.1.

$$\Delta w_0 = 0.000618$$
$$\Delta w_{11} = 0.000237$$
$$\Delta w_{12} = 0.000094$$
$$\Delta w_{13} = 0.000399$$
$$\Delta w_{14} = 0.000272$$
$$\Delta w_{15} = 0.000209$$

Next, the delta factors are added in the hidden layer to obtain the following values:

$$\delta_{in1} = -0.005285$$
$$\delta_{in2} = 0.001718$$
$$\delta_{in3} = -0.001999$$
$$\delta_{in4} = 0.001536$$
$$\delta_{in5} = -0.005241$$

Then the result is multiplied by the derivative of the activation function used by the network to produce an error correction factor δ_j until obtained,

$$\delta_1 = -0.001250$$
$$\delta_2 = 0.000221$$
$$\delta_3 = -0.000457$$
$$\delta_4 = 0.000379$$
$$\delta_5 = -0.001173$$

Determining the error correction value is used to calculate the weight correction value for each output, so that the results in the following table are obtained.

Table 4. Changes in Weight for Each Output

Variable	$\Delta v1$	$\Delta v2$	$\Delta v3$	$\Delta v4$	$\Delta v5$
x1	-0.000104	0.000018	-0.000038	0.000031	-0.000097
x2	-0.000109	0.000019	-0.000040	0.000033	-0.000102
x3	-0.000112	0.0000020	-0.000041	0.000034	-0.000106
x4	-0.000029	0.000005	-0.000011	0.000009	-0.000028
x5	-0.000012	0.000002	-0.000005	0.000004	-0.000012

Meanwhile, changing the input weight to the hidden layer gives the following results:

$$\Delta v_{j1} = -0.0001250$$
$$\Delta v_{j2} = 0.0000221$$
$$\Delta v_{j3} = -0.0000457$$
$$\Delta v_{j4} = 0.0000379$$
$$\Delta v_{j5} = -0.0001173$$

Changes in Weights and Bias

If the backpropagation stage is complete, the next step will be to calculate the changes in weight and bias from the input layer to the hidden layer and from the hidden layer to the output layer. Table 5 below shows the results of changing the weight values from the input layer to the hidden layer.

Table 5. Change in Weight from the Input Layer to the Hidden Layer

Weight	*z1*	*z2*	*z3*	*z4*	*z5*
v1	-0.773104	0.245018	0.218962	0.247031	0.721903
v2	0.280891	-0.980981	-0.535040	0.332033	0.028898
v3	0.386888	0.089020	-0.435041	0.847034	-0.415106
v4	0.674971	-0.427995	-0.466011	-0.626991	-0.536028
v5	-0.367012	-0.394998	-0.682005	-0.919996	-0.562012

To change the hidden weights in the output layer, the following results are obtained:

$$w_{11}(new) = w_1(old) + \Delta w_{11} = -0.855$$
$$w_{12}(new) = w_2(old) + \Delta w_{12} = 0.278$$
$$w_{13}(new) = w_3(old) + \Delta w_{13} = -0.323$$
$$w_{14}(new) = w_4(old) + \Delta w_{14} = 0.249$$
$$w_{15}(new) = w_5(old) + \Delta w_{15} = -0.848$$

Likewise, each hidden unit will update its bias and weight with each input unit, formulated with the equation:

$$v_{j0}(new) = v_{j0}(old) + \Delta v_{j0}$$
$$v_{j01}(new) = -0.375 + (-0.000125) = -0.375$$
$$v_{j02}(new) = -0.697 + 0.0000221 = -0.697$$
$$v_{j03}(new) = 0.438 + (-0.0000457) = 0.438$$
$$v_{j04}(new) = 0.196 + 0.0000379 = 0.196$$
$$v_{j05}(new) = 0.863 + (-0.0001173) = 0.863$$

Next, the weights and bias are updated by calculating the change in bias from the hidden layer to the output layer. The results obtained are

$$w_k = 0.275.$$

Changes in weights and biases continue to be made until one of the stopping factors for the Artificial Neural Network training process is met. If one of these factors has not been met, the process will return to the forward propagation stage (feedforward) by changing the weight and bias values at each layer to influence the output value (B. Yanto, Hendri, Almadison, Hutagaol, & Rahman, 2022). The change process is carried out by, among other things, entering bias and weights according to the calculation results in the backpropagation stage until the target result has been achieved.

The stages carried out in the backpropagation algorithm end with the prediction results. Based on the calculations that have been carried out previously, the output value is obtained, which is then compared with the target to be achieved. The target in question is that many foreign tourists will visit Indonesia via air gates in 2022. The difference between the output value and the target is then called an error. The predicted results of foreign tourist visits to Indonesia via air gates are given in Table 6.

Table 6. Prediction Results of Foreign Tourist Visits to Indonesia Via Air Gate in 2022

No.	Door Name	Target	Output	Error	Prediction Results
1	Ngurah Rai	0.376180	0.4021792	-0.026	2356824.773
2	Soekarno-Hatta	0.219837	0.373617	-0.154	2134056.07
3	Juanda	0.108692	0.3530353	-0.244	1973530.858
4	Kualanamu	0.109552	0.3532113	-0.244	1974903.645
5	Husein Sastranegara	0.100011	0.3525667	-0.253	1969875.672
6	Adi Sucipto	0.101556	0.3523382	-0.251	1968094.016
7	International Airport Lombok	0.101926	0.3521728	-0.250	1966803.491
8	Sam Ratulangi	0.101973	0.3518818	-0.250	1964534.282
9	Minangkabau	0.100531	0.3515588	-0.251	1962015.201
10	Sultan Syarif Kasim II	0.100511	0.3515801	-0.251	1962181.421
11	Sultan Iskandar Muda	0.100242	0.3515225	-0.251	1961731.545
12	Ahmad Yani	0.100000	0.3514446	-0.251	1961124.111
13	Supadio	0.100000	0.3514035	-0.251	1960803.813
14	Hasanuddin	0.100758	0.3514097	-0.251	1960852.295
15	Sultan Badaruddin II	0.100145	0.3513761	-0.251	1960590.37
16	Other Air Doors	0.100685	0.3514803	-0.251	1961403.014
MSE				**0.056**	

The accuracy results for predictions of foreign tourist visits to Indonesia via air gates in 2022 are calculated using the formula,

$$Accuracy(\%) = \frac{Prediction\ Results}{Actual\ Data} \times 100\%$$

Based on the results of calculating accuracy values, it was found that Bali's Ngurah Rai Airport is the airport that has the highest level of accuracy, namely 91.40% with an MSE value of 0.056. This value tends to be small because the Backpropagation algorithm in several prediction cases produces quite good and accurate MSE values (Lestari, Albar, & Afwani, 2019). Furthermore, the level of accuracy for each airport is shown in Figure 4.

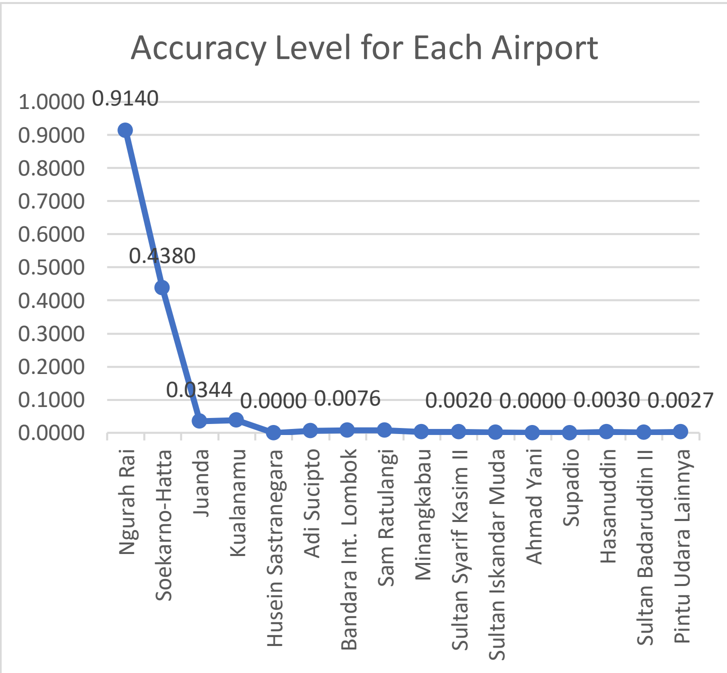

Figure 4. Accuracy Level for Each Airport

CONCLUSIONS AND SUGGESTIONS

From the results of training and testing with the backpropagation algorithm on foreign tourist visits to Indonesia via air gates from 2017–2021 by taking data from at least 16 airports spread across Indonesia, it was found that Bali's Ngurah Rai Airport is the airport that has the highest accuracy level of 91. 4%. Meanwhile, most other airports provide less accurate results because the number of visitors at some of these airports is unstable and has even experienced a significant decline in the pandemic era. From this prediction, an MSE value of 0.056 was obtained; in other words, the prediction results using the backpropagation algorithm can be said to be good and quite accurate and can be used for prediction calculations in the following year.

In this research, the data used was only for six years. In future research, it is recommended that data be used at time intervals of more than 6 years to obtain better prediction results. Additionally, it is recommended to use other software, including Python or Matlab.

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