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Estimation of Closed Hotels and Restaurants in Jakarta as Impact of Corona Virus Disease (Covid-19) Spread Using Backpropagation Neural Network

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Abstract: Corona Virus Disease (Covid-19) has become the focus of world attention because it attacked many people in the world and many people died. The effect of Covid-19 is not only on the health of people, it is negatively affecting all aspects of life including the social area, economy, sport, and tourism. Hotels and restaurants that are an important part of the tourism industry have got a big negative impact from Covid-19. Since this disease has spreaded in many countries including Indonesia, the Indonesian goverment adopted regulations to close the hotels and restaurants to prevent the spread of Covid-19. This research comes from the need to find out the estimated number of hotels and restaurants to be closed due to Covid-19. The estimation method will involve the Backpropagation Neural Network. The Backpropagation Neural Network can make estimation of the number of closed hotels and restaurants approaching the target. Simulations are applied by splitting the dataset into training data (80%) and testing data (20%). From Backpropagation Neural Network simulations, the Backpropagation Neural Network can make estimation of the number of closed hotels and restaurants in training data with optimal RMSE being 9.2422 and testing data with optimal RMSE being 8.9419.

Keywords: *backpropagation; neural network; estimation; Covid-19.*

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1 Introduction

In early 2020, Corona Virus Disease (Covid-19) has become the focus of world attention because it attacked many people in the world and many people died. This disease was firstly found in China and then it spreaded worldwide, including Indonesia. Covid-19 is the disease caused by the Corona virus resembling SARS so that it is named SARS-CoV2. The symptoms of this disease are fever, tiredness, dry cough, sore throat, difficulty in breathing or shortness of breath.

Because this disease has spreaded in many countries including Indonesia, the Indonesia goverments adopted regulations to close the hotels and restaurants to prevent the spread of Covid-19. The tourism industry is the industry that has multiplier effect in a country or region. This industry is strongly affected by Covid-19 and it will need a long time to recover. Hotels are one of the biggest players in the tourism industry. Many new hotels are built in tourism cities and metropolitan cities such as Jakarta and Surabaya [1, 2]. Jakarta is the city in Indonesia where the first victim came and the city with the most Covid-19 positive victims. Because of that, the estimation of the number of closed hotels and restaurants in Jakarta is important to be done. In this research, the estimation method will involve the Backpropagation Neural Network [3].

A neural network (NN) was introduced by McCulloch and Pitts in 1943. The NN work resembles that of the human neuron system. The type of a Neural Network used in the estimation process is Backpropagation. Backpropagation consists of forward propagation, backward propagation, and updating weight matrices. In forward propagation, some computations using an activation function start from the input, hidden layer, and output, respectively. In backward propagation, error factor computations are applied from the output, hidden layer, and input, respectively. After that, we update weight matrices [4,5].

In the previous research, forecasting methods for estimation have been applied by exponential smoothing [1], Kalman Filter on mobile robot trajectory [6], Kalman Filter Estimation [7], Autonomous Underwater Vehicle Optimization [8–10] steam temperature and water level estimation [11], stock price estimation [12, 13], crude oil and profitability estimation [14–16], Blood Stock Estimation [17, 18], arm robot motion estimation [19], and fuzzy logic by the Adaptive Neuro Fuzzy Inference System [20]. Backpropagation has been applied in weather prediction [2, 21] with various types of data [22]. This algorithm is applied in training data and testing data in a certain proportion. In this research, the Backpropagation Neural Network will be used for estimating the number of closed hotels and restaurants in Jakarta. In making estimation of the number of closed hotels and restaurants using the Backpropagation Neural Network, some inputs are required such as the number of positive victims in Jakarta, the number of recovered victims in Jakarta, the number of dead victims in Jakarta, the number of positive victims in Indonesia, the number of recovered victims in Indonesia, the number of dead victims in Indonesia, the number of positive victims in the world, the number of recovered victims in the world, and the number of dead victims in the world.

From Backpropagation Neural Network simulations, the Backpropagation Neural Network can make estimation of the number of closed hotels and restaurants in training data with optimal RMSE being 9.2422 and testing data with optimal RMSE being 8.9419. We also repeat these simulations five times.

2 Literature Review

A Neural Network was introduced by Mc Culloch and Pitts in 1943. The behavior of a Neural Network is as follows [23]: (a) the signal is traveling between neurons through a connector; (b) connectors have weight which will either increase or decrease the signal; (c) to determine the output, a neuron uses an activation function applied in the sum of inputs received.

In a Neural Network, an activation function is used for determining the output of a neuron. The argument of an activation function is a linear combination of the input and weight as in equation (1):

$$net = \sum_i x_i w_i, \quad f(net) = f\left(\sum_i x_i w_i\right). \tag{1}$$

The activation function used is continuous, differentiable, and not descending function [4]. In this research, the activation function applied is binary sigmoid with the range (0-1) as in equation (2):

$$\begin{aligned} f(net) &= \frac{1}{1+e^{-net}}, \\ f'(net) &= f(net)(1-f(net)). \end{aligned} \tag{2}$$

Backpropagation is a type of the Neural Network used in the estimation process. Backpropagation consists of some inputs $x_1, x_2, \ldots, x_n$, some hidden layer $z_1, z_2, \ldots, z_p$, and some output $y_1, y_2, \ldots, y_m$. In the input and hidden layer, there is bias with value 1. Weight v_{ij} connects input x_i to hidden layer z_j. Weight w_{jk} connects hidden layer z_j to output y_k. In Backpropagation, there are three phases of calculation such as forward propagation, backward propagation, and update weight matrices [4]. A backpropagation model can be seen in Figure 1.

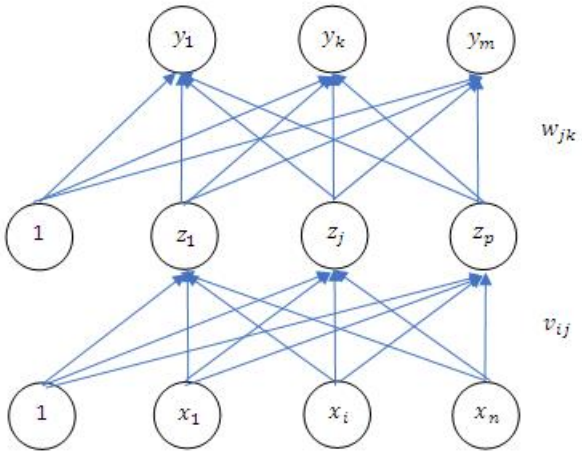

Figure 1: Backpropagation Neural Network Model.

The algorithm of a Backpropagation Neural Network is as follows:

Initialization weight matrices V and W with random number between -0.5 to 0.5.
$e = 1$
$while(e \leq max\_epoch \&\& MSE \geq min\_MSE)$
$for(d = 1 : datasize)$

1. Each input receives a signal which continues to each hidden layer through forward propagation in equation (3) until equation (6) and backward propagation in equation (7) until equation (11).
   Forward Propagation
2. All outputs $z_j, j = 1, 2, \ldots, p$ are calculated in the hidden layer in equation (4).

$$z\_net_j = v_{oj} + \sum_{i=1}^{n} x_i v_{ij}, \tag{3}$$

$$z_j = f(z\_net_j) = \frac{1}{1 + e^{-z\_net_j}}. \tag{4}$$

3. Calculate all outputs $y_k, k = 1, 2, \ldots, m$, in equation (6).

$$y\_net_k = w_{ok} + \sum_{j=1}^{p} z_j w_{jk}, \tag{5}$$

$$y_k = f(y\_net_k) = \frac{1}{1 + e^{-y\_net_k}}. \tag{6}$$

   Backward Propagation

4. Calculate the factor δ output based on the error in each output $y_k, k = 1, 2, \ldots, m$,

$$\delta_k = (t_k - y_k) f'(y\_net_k). \tag{7}$$

5. Calculate the weight update

$$\Delta w_{jk} = \alpha \delta_k z_j, \;\; k = 1, 2, \ldots, m, \; j = 0, 1, 2, \ldots, p. \tag{8}$$

6. Calculate the factor δ hidden layer in equation (10) based on the error in each hidden layer $z_j, j = 1, 2, \ldots, p$,

$$\delta\_net_j = \sum_{k=1}^{m} \delta_k w_{jk}, \tag{9}$$

$$\delta_j = \delta\_net_j f'(z\_net_j). \tag{10}$$

7. Calculate the weight update

$$\Delta v_{ij} = \alpha \delta_j x_i, \;\; j = 1, 2, \ldots, p, \; i = 0, 1, 2, \ldots, n. \tag{11}$$

   Update Weight Matrices

8. Update the new weight matrices

$$w_{jk} = w_{jk} + \Delta w_{jk}, \tag{12}$$

$$v_{ij} = v_{ij} + \Delta v_{ij}. \tag{13}$$

end
Compute the root of mean square error (RMSE)

$$RMSE = \sqrt{\frac{1}{datasize} \sum_{d=1}^{datasize} \frac{1}{m} \sum_{k=1}^{m} (T_{dk} - Y_{dk})^2}, \tag{14}$$

where T_{dk} is the target value and Y_{dk} is the output.
$e = e + 1$
end

3 Result and Discussion

Datasets are taken from the report of closed hotels and restaurants from March 1, 2020 until April 30, 2020 (61 days), issued by the Indonesian Hotels and Restaurants Association, with the observed area of Jakarta as the first city where Covid-19 was first discovered. These data will be estimated by the Backpropagation Neural Network.

In addition, there are the data of the number of Covid-19 victims (positive, recovered, dead) in Jakarta from March 1, 2020 until April 30, 2020, obtained from the official Covid-19 Jakarta website, the data of the number of Covid-19 victims (positive, recovered, dead) in Indonesia from March 1, 2020 until April 30, 2020, obtained from the Ministry of Health, Republic of Indonesia, and the data of the number of Covid-19 victims (positive, recovered, dead) in world from March 1, 2020 until April 30, 2020, obtained from the Worldometer website. They will be used as inputs in the Backpropagation Neural Network, where the output is the number of closed hotels and restaurants in Jakarta from March 1, 2020 until April 30, 2020, as estimations.

3.1 Data Used

The graph of the number of closed hotels and restaurant from March 1, 2020 until April 30, 2020, in Jakarta can be seen in Figure 2.

For estimating the number of closed hotels and restaurants by the Backpropagation Neural Network, we need some inputs such as the number of positive victims in Jakarta, the number of recovered victims in Jakarta, the number of dead victims in Jakarta, the number of positive victims in Indonesia, the number of recovered victims in Indonesia, the number of dead victims in Indonesia, the number of positive victims in the world, the number of recovered victims in the world, and the number of dead victims in the world.

The graph of the number of Covid-19 victims in Jakarta from March 1, 2020 until April 30, 2020, can be seen in Figure 3. There are three parts of the graph with different colors that are the number of positive victims, the number of recovered victims, and the number of dead victims.

The graph of the number of Covid-19 victims in Indonesia from March 1, 2020 until April 30, 2020, can be seen in Figure 4. There are three parts of the graph with different

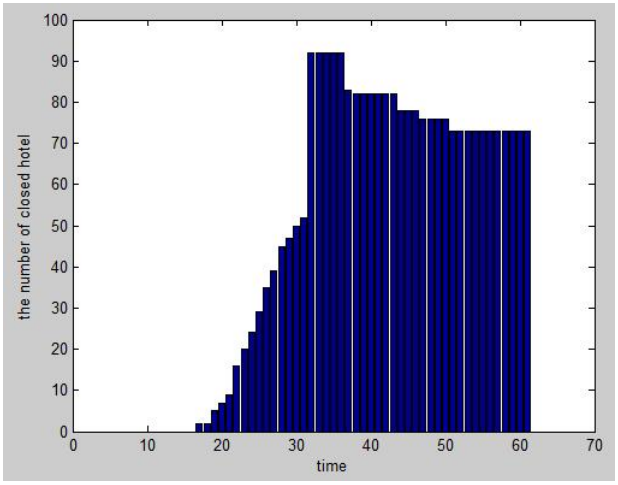

Figure 2: The number of closed hotels and restaurants.

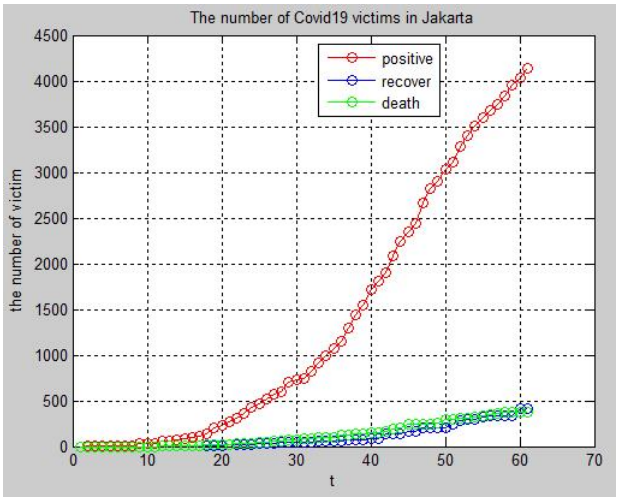

Figure 3: The number of Covid-19 victims in Jakarta.

colors that are the number of positive victims, the number of recovered victims, and the number of dead victims.

The graph of the number of Covid-19 victims in the world from March 1, 2020 until April 30, 2020, can be seen in Figure 5. There are three parts of the graph with different colors that are the number of positive victims, the number of recovered victims, and the number of dead victims.

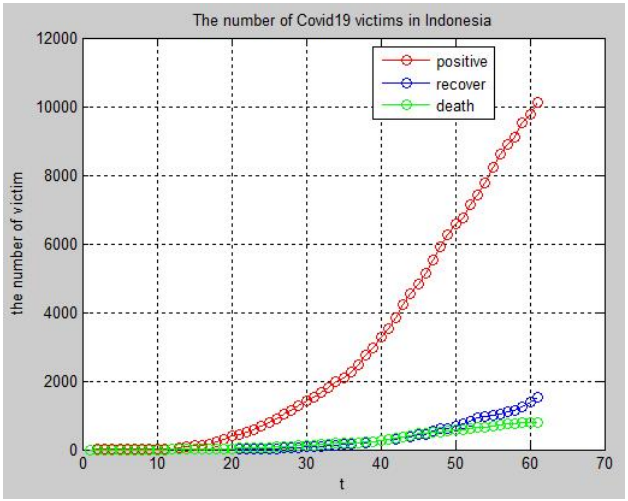

Figure 4: The number of Covid-19 victims in Indonesia.

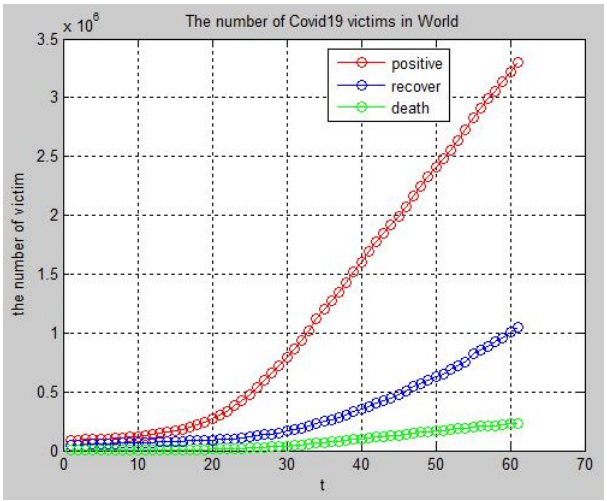

Figure 5: The number of Covid-19 victims in the world.

3.2 Estimation Results

Before applying the estimation process, we need to split the data into training data and testing data. The data partition used is as follows: for training data, the data used have the proportion of 80% of all data, while for testing data, the data used have the remaining proportion (20% of all data). Figure 6 shows the data partition, where the red plus marks represent the distribution of testing data, and the blue ones represent training data.

The parameters used in the Backpropagation Neural Network simulation are:

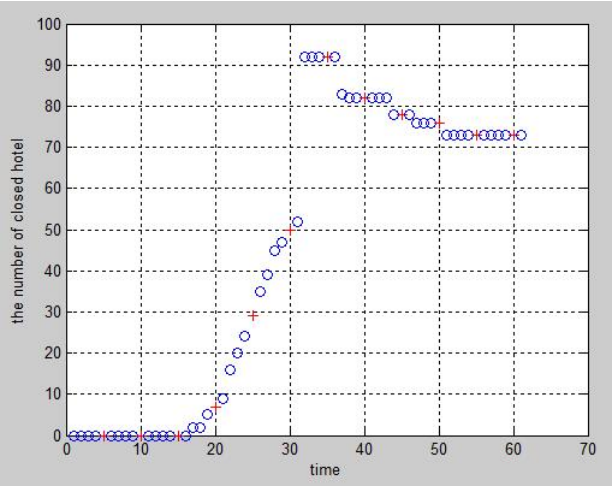

Figure 6: Data partition into training data (blue) and testing data (red).

Learning rate : 0.2.
The number of hidden layer : 2.
Maximum epoch : 1000.
The model of backpropagation : 9 (input) – 10 (hidden layer 1) – 10 (hidden layer 2) – 1 (output).

The simulation of the Backpropagation Neural Network can be seen in Figures 7, 8 and 9 below. First, initialize the weight matrices and apply to training data using the Backpropagation Neural Network until the maximum epoch, the convergence process can be seen in Figure 7. It can be seen in the early epoch, the RMSE resulted is quite large. In the optimization, the RMSE is decreased and converged. Figure 8 shows the comparison and error between the target and output. From the training process until 1000 epochs, optimal weight matrices are obtained. Then, the optimal weight matrices are applied to testing data. Figure 9 shows simulation for testing data.

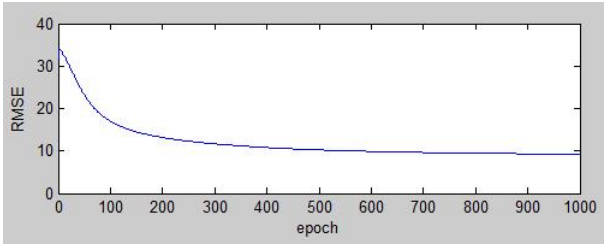

Figure 7: Convergence Process of the Backpropagation Neural Network.

From the simulation, we obtain the estimation with the root of mean square error (RMSE) in equation (14) as follows:
Training data : 9.2422.
Testing data : 8.9419.

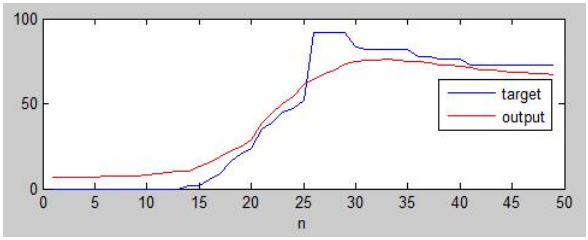

Figure 8: Estimation result for training data.

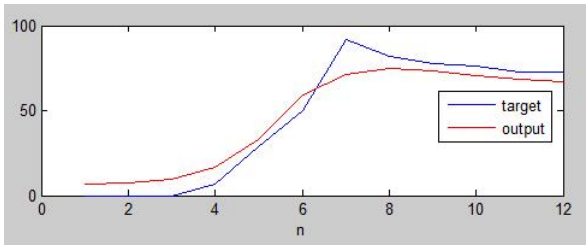

Figure 9: Estimation result for testing data.

We repeat the simulations five times using different initial weights and the results are given in Table 1.

Number	Max epoch	RMSE for training data	RMSE for testing data
1	1000	9.5604	9.3628
2	1000	9.0513	8.7649
3	1000	9.0156	8.8002
4	1000	9.1428	8.9463
5	1000	8.9626	8.6265

Table 1: The root of mean square error (RMSE) in the Backpropagation Neural Network with five times trials.

4 Conclusion

The corona virus (Covid-19) has been negatively affecting the hotels and restaurants businesses. Hotels and restaurants have become a primary need of the business people, especially in a big city like Jakarta. The closed hotels and restaurants due to Covid-19 are also affecting the tax income of the government as well as the income of the suppliers. In making estimation of the number of closed hotels and restaurants using the Backpropagation Neural Network, some inputs are required, such as the number of positive victims in Jakarta, the number of recovered victims in Jakarta, the number of dead victims in Jakarta, the number of positive victims in Indonesia, the number of recovered victims in Indonesia, the number of dead victims in Indonesia, the number

of positive victims in the world, the number of recovered victims in the world, and the number of dead victims in the world.

The Backpropagation Neural Network can make estimation of the number of closed hotels and restaurants approaching the target. Simulations are applied by splitting the dataset into training data (80%) and testing data (20%). From Backpropagation Neural Network simulations, the Backpropagation Neural Network can make estimation of the number of closed hotels and restaurants in training data with optimal RMSE being 9.2422 and testing data with optimal RMSE being 8.9419.

The developments of this research are making estimation and classification of the results by data mining and machine learning techniques.

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