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Comparison and Analysis of the Artificial Neural Network Method and SIRD on Covid-19 Cases in Surabaya

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Abstract. Since the first case of Covid-19, it is evidence that the spread of the disease in Indonesia is unavoidable. The virus continues to be widespread in Indonesian cities, one of which is Surabaya. Surabaya attained the 'crimson zone' status on June 2, 2020 due to the drastic increase of positive Covid-19 cases which tallies to 2748 people. The rapid pace at which Covid-19 spreads can result in a high death rate. This research tries to prevent high casualty rates by predicting the need for health equipment, isolation rooms, medical personnel, and the need for Personal Protective Equipment (PPE) for Covid-19 patients. There are two methods used for the sake of predicting, namely the Artificial Neural Network (ANN) and Susceptible Infectious Recovered Decease (SIRD) methods. The methods being mentioned will have their accuracies tested using error measurement methods which include the Mean Absolute Deviation (MAD), Mean Square Error (MSE), and Mean Absolute Percentage Error (MAPE). After measurements have been made, the prediction results from these 2 methods will be utilized to calculate the needs for equipment, isolation rooms, medical personnel, and PPE needs based on the regulatory patterns owned by the S, N, and X hospitals. Based on the results of the website implementation analysis, the ANN method is shown to have average error rates of 68,7467 for training and 75,4533 for testing based on the MAD method, 12487,67 for training and 13957,9267 for testing based on the MSE method, and 19,57% for training and 17,6% for testing based on the MAPE method. The SIRD method is shown to have average error rates of 551,1533, 1072639,5567, and 26,3033% for the MAD, MSE, and MAPE methods respectively.

1. Introduction

The only 2 months and 4 days after the official announcement on March 2, 2020, there was an increase in the number of people infected with Covid-19 by 3,04% or 367 people within one day. The spread of the Covid-19 virus continues to develop and spread in various cities in Indonesia until now.

Indonesia has many cities, one of which is Surabaya. On June 2, 2020, Surabaya entered the 'crimson zone' because it had an additional 2,748 positive Covid-19 cases [6]. Based on a WHO report as of May 6, 2020, the number of deaths caused by the virus continues to increase alongside with the increasing number of positive cases [9]. One way to prevent a high death toll is to predict the need for ventilators, isolation rooms, medical personnel, and the need for Personal Protective Equipment (PPE) for Covid-19 patients [8]. The method that can be used to predict is the Artificial Neural Network (ANN), while the epidemiological method is used to detect disease transmission, namely Susceptible Infectious Recovered Decease (SIRD).

The use of the ANN method has been used in Covid-19 cases in Egypt [4]. Egypt uses a combination of Nonlinear Autoregressive with ANN to prevent the higher outbreak of Covid-19 in the future. However, in this prediction Nonlinear Autoregressive is compared with the Autoregressive

Integrated Moving Average (ARIMA) [6], while there is no comparison with the Susceptible Infectious Recovered (SIR) method.

The SIR model is an epidemiological model for calculating the theoretical number of people infected with an infectious disease in a closed population over time [6]. However, SIRD is a breakdown of the SIR model by dividing people who recover and decease. The use of this SIR model has been used in the case of the Covid-19 virus in Japan through improvisation of the use of Asymptotic Approximants [1]. Asymptotic Approximants are good at improving the accuracy of predictions, but this paper does not break down SIR into SIRD and compare SIR models with other models.

Through scientific research on the prediction of the Covid-19 virus in Surabaya, the ANN and SIRD methods are used. This method is one of the methods used as a support for data analysis. Through the two methods used, they are expected to help adding references to the Covid-19 Response Acceleration Task Force. Furthermore, they can help in dealing with similar virus outbreaks in the future. A disturbing incident is any form of security breach, whether intentional or not, that causes economic growth to not run normally [5].

2. Literature Review

This section discusses some of the terms in prediction method.

2.1. Artificial Neural Network (ANN)

Artificial Neural Network (ANN) is "an information processing system that has performance characteristics like biological neural networks" [2]. ANN works with the assumption that:

1. Information processing occurs in an element called neuron.
2. Signals are sent between neurons by means of a connection.
3. Each connection has a weight multiplied by the value of the signal sent.
4. Each neuron that wanted to be converted as output must go through an activation function.

Based on this method, the formula for neurons in equation 1 is obtained.

$$Neuron = \sum_{i=1}^{n} x_i w_i + \cdots + x_n w_n + b \quad (1)$$

2.2. Susceptible Infectious Recovered Decease (SIRD)

The Susceptible Infectious Recovered (SIR) model is an epidemiological model that calculates the theoretical number of people infected with an infectious disease in a closed population over time [7]. SIR consists of 3, namely Susceptible, Infectious, and Recovered, so the formula for these three things is different. The formula for the Susceptible derivative is shown in equation 2 [7].

$$\frac{dS}{dt} = -\frac{\beta}{N} S(t)I(t) \quad (2)$$

Equation 2 explains that the increase in people who are susceptible to disease is obtained through the number of people who are susceptible compared to the total population in a given area multiplied by the number of people infected with the rate of infected people that can spread it. Equation 2 uses a minus because people who are susceptible over time will definitely decrease because they are infected with the disease. The increase in the infected person is shown in equation 3 [7].

$$\frac{dI}{dt} = \frac{\beta}{N} S(t)I(t) - \gamma\, \mathrm{I(t)} \quad (3)$$

Equation 3 explains that the increase in infected people is obtained based on the increase in susceptible people, then the infection is reduced by the number of people who experience recovery or die. The increase in people who died or recovered is shown in equation 4.

$$\frac{dR}{dt} = \gamma\, \mathrm{I(t)} \quad (4)$$

Equation 4 explains that the increase in the number of people who die or recover is obtained through the rate of disease lost multiplied by those infected. However, SIRD is a more detailed method than SIR. SIR combines people who recovered and died in one variable, recovered, whereas SIRD distinguishes the number of people who recovered and died in 2 variables, namely Decease and Recovered. The process of this method is depicted in Figure 1.

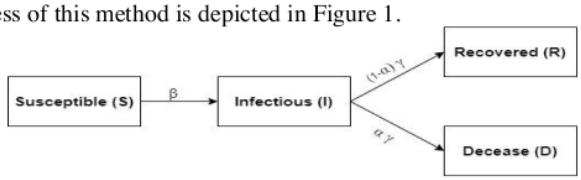

Figure 1. SIRD Process

3. Methodology

3.1. Data Processing Sources

The data is taken from the hospital which is a health service institution that provides complete individual health services that provide inpatient, outpatient and emergency services [3]. At the time of the Covid-19 pandemic, this hospital was categorized into 2, namely the Covid-19 referral hospital and the non-Covid-19 referral hospital. The data that will be used is from 3 Covid-19 referral hospitals in Surabaya as a sample.

3.2. Covid-19 Case Resources

The data source for the Covid-19 case was taken from the Surabaya Government's Covid-19 response page. The types of data taken were cases of care, recovery, and death. Data taken from March 2, 2020 to December 31, 2020, but used starting from March 26, 2020 to December 31, 2020 because the value of recovery and death from the data before March 26 was 0.

4. System result

4.1. Website Application Testing

Testing of the website application is carried out after all data obtained from the hospital and the number of Covid-19 are entered into the database. The display in ANN predictions can be seen in Figure 2.

Figure 2. ANN Prediction Training and Testing Results

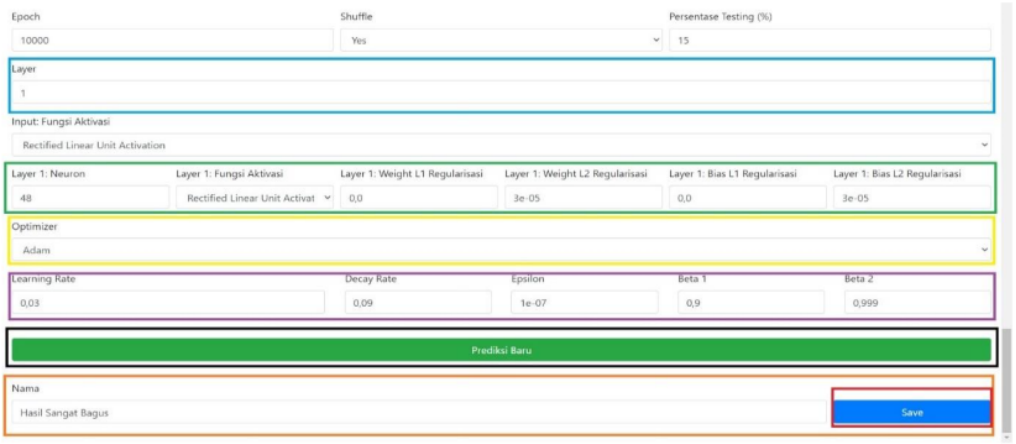

Figure 3. ANN Predictions Form

Each result in Figure 2 this training and testing has a measurement error using the Mean Absolute Deviation (MAD), Mean Absolute Percentage Error (MAPE), and Mean Square Error (MSE) method which is shown in the red pointer box. At the bottom of the training and testing results are the patient's needs, namely the number of types of rooms, supply, equipment, doctors, and nurses per day in a city. In Figure 3 there is a blue pointer box which is useful for changing the number of layers used in the green pointer box. In Figure 3, there is also a yellow box as an input for the optimization method which is useful for changing the purple pointer box as the attributes of the optimization data.

The feature for making predictions with the SIRD model is on the SIRD Prediction page. The top view of the SIRD Prediction page can be seen in Figure 4. In Figure 4 on the left there is a graph of the prediction results using the SIRD method and the right side is a graph for the gradient, gamma, and beta values for each prediction date.

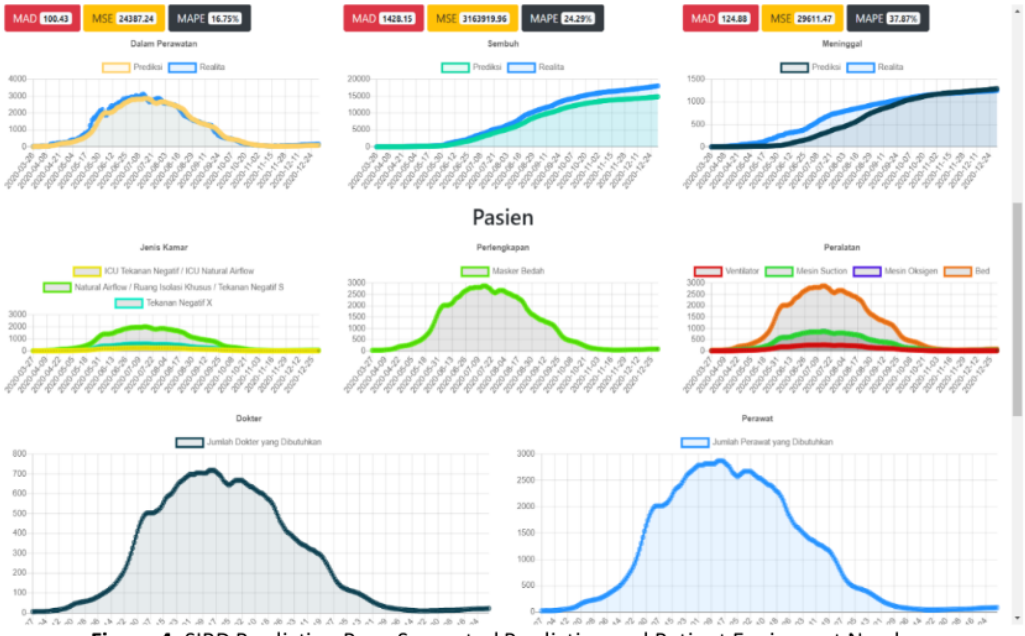

Figure 4. SIRD Prediction Page Separated Prediction and Patient Equipment Needs

4.2. Evaluation of Accuracy Methods and Needs During Covid-19

Accuracy evaluation is done using Artificial Neural Network (ANN) and Susceptible Infectious Recovered Decease (SIRD) methods. The first process carried out to evaluate accuracy is to calculate predictions from existing data. After making predictions, the results of the predictions will be used to measure the error value of the ANN and SIRD methods on MAD, MSE, and MAPE [7]. The error values obtained from MAD, MSE, and MAPE for ANN training can be seen in Table 1, ANN testing can be seen in Table 2 and SIRD can be seen in Table 3.

Table 1. Error Calculation on the Results of Training Prediction

Measurement Error Types	Infectious	Deceased	Recovered	Average
MAD	52,76	14,95	138,53	68,7467
MSE	4829,65	331,51	32330,94	12497,367
MAPE	20,87%	18,04%	19,8%	19,57%

Table 2. Error Calculation on Prediction Testing Results

Measurement Error Types	Infectious	Deceased	Recovered	Average
MAD	64,55	16,19	145,62	75,4533
MSE	8418,17	413,84	33041,77	13957,9267
MAPE	16,67%	19,48%	16,65%	17,6%

Table 3. Calculation of Error on SIRD Prediction Results

Measurement Error Types	Infectious	Deceased	Recovered	Average
MAD	100,43	124,88	1428,15	551,1533
MSE	24387,24	29611,47	3163919,96	1072639,5567
MAPE	16,75%	37,87%	24,29%	26,3033%

In addition to measuring error values, predictive results can be used for patient needs. There are various kinds of patient needs, namely equipment, supply, types of rooms, doctors, and nurses. The calculation for supply needs is carried out by multiplying the number of predictions in the care of Covid-19 patients with the need for level 0 Personal Protective Equipment (PPE). The use of PPE that is used when the patient is undergoing treatment in the hospital is a surgical mask. Surgical masks are used by patients because when the patient is hospitalized, the patient must have symptoms related to Covid-19.

In addition to patient needs, a hospital also has PPE needs that come from non-medical personnel, non-Covid doctors, nurses and Covid doctors [9]. Hospital S uses PPE Level 1 summarize 210 non-medical personnel and 60 non-Covid doctors, PPE Level 2, namely 3 non-medical personnel, and PPE Level 3, namely 8 Covid doctors and 52 nurses. Hospital N uses PPE Level 1, namely 97 non-medical personnel and 70 non-Covid doctors, Level 2 PPE, namely 3 non-medical personnel, and PPE Level 3, namely 4 Covid doctors and 40 nurses. Hospital X uses PPE Level 1, namely 500 non-medical personnel and 79 non-Covid doctors, PPE Level 2, which is 3 non-medical personnel, and PPE Level 3, namely 10 Covid doctors and 39 nurses.

Based on data on the use of PPE for each hospital, the results of calculating the needs of the 3 rounded hospitals can be seen in Table 4.

Table 4. Fixed Needs for Hospital Equipment

Type of Needs	S Hospital	N Hospital	X Hospital	The Average of Needs
N95 Mask	60	44	49	51
Single Use Rubber Glove	333	214	631	393
Surgical Mask	273	170	582	342
Gown	63	47	52	54
Face Shield	60	44	49	51
Headcap	63	47	52	54
Apron	60	44	49	51
Goggles	63	47	52	54
Shoe Protector	60	44	49	51

5. Conclusion

Based on the results and analysis of system testing, it can be concluded that:

- In predicting the case of the Covid-19 virus in Surabaya, the Artificial Neural Network (ANN) method can provide an error rate using the Mean Absolute Deviation (MAD) error measurement method averaging 68,7467 for training and 75,4533 for testing, the average of Mean Squared Error (MSE) is 12497,367 for training and 13957,9267 for testing, and the average of Mean Absolute Percentage Error (MAPE) is 19,57% for training and 17,6% for testing so that the average's accuracy of the ANN is 80,43% for training and 82,4% for testing. The Susceptible Infectious Recovered Decease (SIRD) method can provide an error rate with an average MAD error measurement method of 551,1533, an average of MSE of 1072639,5567, and an average of MAPE of 26,3033% so that the average accuracy of SIRD is 73,6967%. This shows that the accuracy of ANN, both training and testing, is better used than SIRD.
- The prediction using the ANN and SIRD methods along with the process of obtaining data from 3 hospitals, it was found that the need for equipment was 1 to 1 with the patient's PPE needs. However, the medical personnel, namely doctors and nurses, have differences and similarities. Doctors compared to the number of patients had a ratio of 1 doctor to 7 patients, while nurses were 1 nurse to 1 patient. This provides insight that when there is an additional 7 patients, there will be additional 8 of PPE level 3 equipment obtained from 7 nurses and 1 doctor per day. Then in the number of isolation rooms, namely the total number of patients treated will cause 9,44% of all patients to occupy the Negative Pressure / Airflow ICU room which contains 1 ventilator, 1 suction machine, 1 oxygen machine, and 1 bed. 20,6% of all patients will occupy the Negative Pressure room of hospital X which contains 1 suction machine and 1 oxygen machine. 69,96% of all patients will occupy a special isolation room which contains only 1 bed.

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