Research Paper

Using an Artificial Neural Network Model to Predict the Number of COVID-19 Cases in Iran

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ABSTRACT

Background: Forecasting methods are used in various fields including the health problems. This study aims to use the Artificial Neural Network (ANN) method for predicting coronavirus disease 2019 (COVID-19) cases in Iran.

Materials and Methods: This is a descriptive, analytical, and comparative study to predict the time series of COVID-19 cases in Iran from May 2020 to May 2021. An ANN model was used for forecasting, which had three Input, output, and intermediate layers. The network training was conducted by the Levenberg-Marquardt algorithm. The forecasting accuracy was measured by calculating the mean absolute percentage error.

Results: The mean absolute error of the designed ANN model was 6 and its accuracy was 94%.

Conclusion: The ANN has high accuracy in forecasting the number of COVID-19 cases in Iran. The outputs of this model can be used as a basis for decisions in controlling the COVID-19.

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1. Introduction

The coronavirus disease 2019 (COVID-19) has created significant threats to the public health in the world [1]. Despite the remarkable progress in fighting diseases, infectious diseases still have particular importance in epidemiology and public health [2]. The COVID-19 is one of the contagious and infectious diseases of the 21st century, which was first reported in Wuhan, China at the end of December 2019 [3]. The COVID-19 pandemic has affected all aspects of human life [4]. In the beginning, it was assumed that it is a disease like other diseases and can be controlled [5], but it highly affected people's lives in the world [6]. One of the problems that caused the spread of COVID-19 in different countries was the lack of a proper planning to deal with the disease [7]. Incorrect prediction of its risks caused an increase in the number of casualties and patients [8]. One of the essential factors in controlling infectious diseases is the correct and timely actions of governments against this disease [9]. The decisions of governments can be helpful when they are made based on the correct information [5]. The prediction of disease risks can lead to making more correct decisions and a better understanding of problems when it has high accuracy [8]. The COVID-19 pandemic has disrupted the social and economic life of people [10]; testing and measuring the accuracy of prediction methods can be beneficial to estimate its future trends. Various statistical methods have been used to predict or measure the accuracy of prediction methods [11-15]. The artificial neural network (ANN) models have been applied for predicting the risks of diseases in other countries [14, 16]. In this study, we aim to use the ANN model to predict the number of COVID-19 cases in Iran and also measure the accuracy of these models, which can be a road map for the use of forecasting methods in future studies.

2. Materials and Methods

This is a descriptive, analytical, comparative study. The study population consists of all people infected with COVID-19 in Iran from May 21, 2020 to May 21, 2021. Three input, output, and intermediate layers were used for prediction by the ANN model. A combination of essential computational processing elements connected to each other was used in the form of layers. These processing elements called "neurons" simulate a multi-input nonlinear processor [17]. Connections between neurons have different coefficients. Each neuron receives all inputs with different weights and combines them [18]. The combined inputs are passed through the activation function to produce an output, which can be used as an input to other units [19]. After receiving daily statistics of infected cases, the appropriate ANN model was designed. A genetic algorithm was used for network learning. The ANN was univariate for making predictions. After designing and reaching the optimal ANN model and the optimal number of layers, network training was conducted using Levenberg-Marquardt algorithm (LMA), which finds the minimum of a multivariable nonlinear function.

Finally, the model output was obtained. The LMA interpolates between the Gauss-Newton algorithm and the gradient descent method. The LMA is more robust than the Gauss-Newton algorithm, which means that it often finds a solution even if it starts far from the final minimum. On the other hand, for well-behaved functions and reasonable starting parameters, LMA is slightly slower than the Gauss-Newton algorithm. The LMA is the most popular method for solving curve-fitting problems. The accuracy of ANN prediction or the mean absolute percentage error (MAPE) was finally measured.

3. Result

The time series of cases infected with COVID-19 in Iran from May 21, 2020 to May 21, 2021 are shown in Figure 1. The designed ANN had 12 inputs. The ANN divided the data into two categories of testing and training, as shown in Table 1. Table 2 shows the results of assessing the accuracy of the designed ANN model in forecasting the COVID-19 cases. The errors of the forecasted values based on the ANN model is plotted in Figure 2. The trained ANN model was finally used for 30-day out-of-sample forecasting, whose results are shown in Table 3. Figure 3 shows the mechanism of reaching the best answer.

4. Discussion

The out-of-sample forecasting values obtained from the ANN model designed in this study showed that the accuracy of the ANN model in forecasting the COVID-19 cases in Iran was 94%, and the ANN was able to estimate the number of infected cases in Iran. Its error rate was 6%, indicating the very high accuracy of the model. In the study by Omidi et al, who investigated the use of ANN in health systems and forecasting injury risks, the ANN model was highly accurate [17]. In Borghi et al.'s study, the ANN was also highly accurate in forecasting the time series of COVID-19 [14]. Comparing the ANN model with other methods in Maestrini et al.'s study showed that the accuracy of

Table 1. ANN model specifications for forecasting the COVID-19 cases

Network Training	LMA
Activation function	Linear sigmoid
Input layer	1
Output layer	1
Intermediate layer	1
Input neurons	12
Output neurons	1
Optimal number of neurons in the Intermediate layer	7
Stoppage of training	At 25000 iterations (Acceptable error)

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Table 2. Testing the accuracy of the ANN model in forecasting the COVID-19 cases

Variables	Infected Cases (n=365)	
	Test Data	Training Data
Number of data	60	293
Mean absolute error	93.28974665	46.56764502
Mean square error (MSE)	14170.9563	6831.884784
Percentage of correct (good) forecasts	88%	81%
Percentage of wrong (bad) forecasts	12%	19%
MAPE	0.061	-

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Table 3. Out-of-sample forecasted values using the ANN model

Future Steps	Number of Infected Cases	Future Steps	Number of Infected Cases	Future Steps	Number of Infected Cases
1	4328	11	5868	21	4358
2	4653	12	4414	22	4247
3	5712	13	4112	23	5530
4	4308	14	5588	24	5315
5	5603	15	5772	25	4877
6	5992	16	4225	26	5453
7	5949	17	4522	27	5732
8	5145	18	4879	28	4127
9	5748	19	5113	29	4351
10	4739	20	4320	30	4358
MAPE	0.061	-	-	-	-

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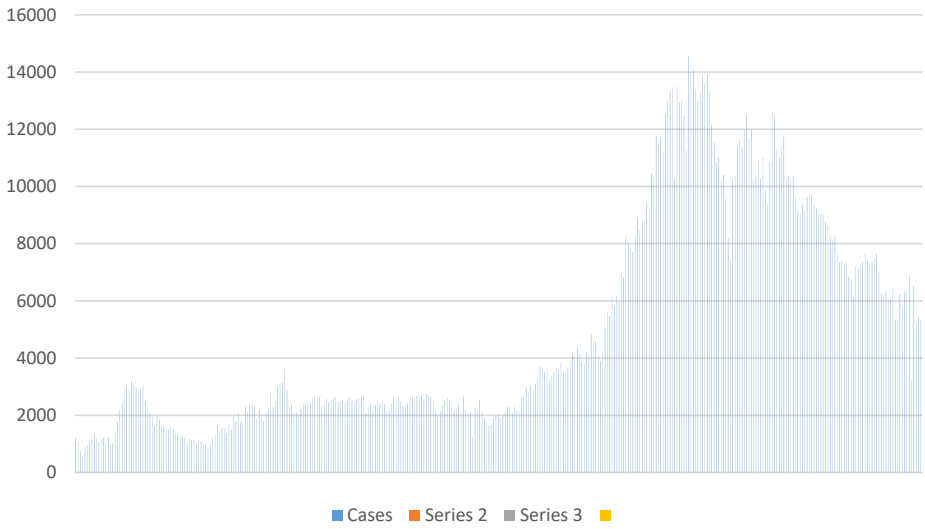

Figure 1. The time series of COVID-19 cases in Iran from May 21, 2020 to May 21, 2021

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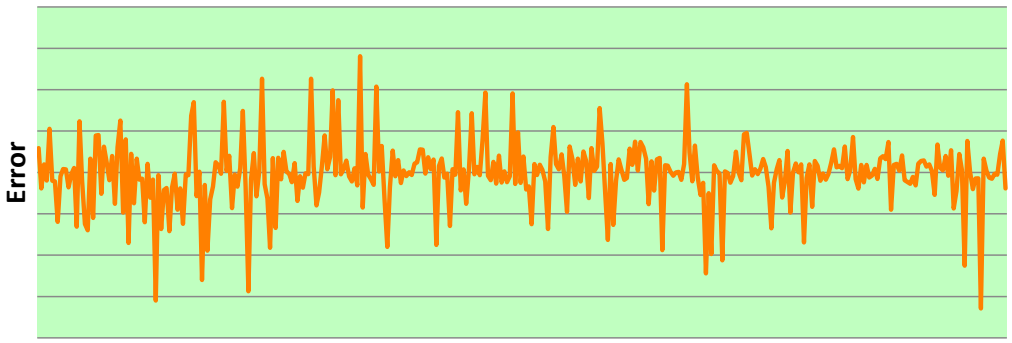

Figure 2. The forecasting errors of the ANN

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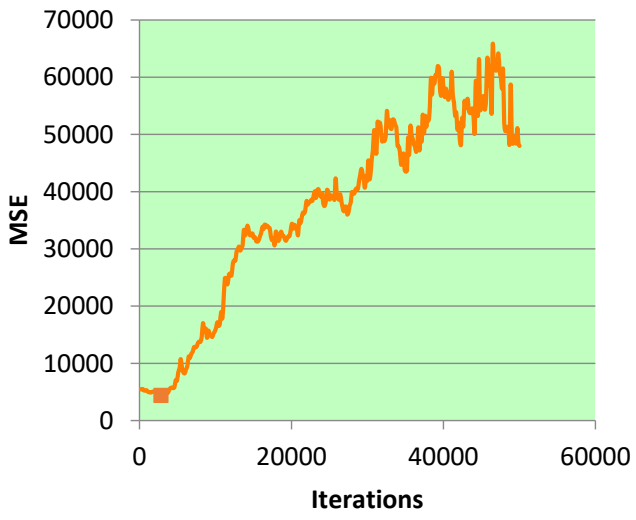

Figure 3. MSE vs. iteration numbers in the ANN model

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the AANN was higher [20]. The ANN model accuracy in our study was higher than that in the studies by Asgari et al. and Omidi et al. [18, 19].

The proper design of ANN plays a significant role in the accuracy of forecasting . The important factors in the proper design of the ANN are the optimal number of input, output, and intermediate layers, the number of neurons in each layer, and how to train the mdoel. The ANN model in our study had 12 inputs. For network training, the LMA was used. The optimal number of input, intermediate, and output layers was 1, and the optimal number of neurons in the intermediate layer was 7. Asgari et al. and Omidi et al. [18, 19] examined the ANN design accuracy in the forecasting, and showed that the design of ANN had a significant impact on the final accuracy of the ANN model.

5. Conclusion

The ANN model has high accuracy in forecasting the number of COVID-19 cases in Iran. The outputs of this model can be used as a basis for decisions in controlling the COVID-19.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages.

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Authors' contributions

Both authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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