Forecasting Daily Covid-19 Deaths in Canada Using Artificial Neural Networks

[1]**Dr. Smartson. P. NYONI,** [2]**Thabani NYONI,** [3]**Tatenda. A. CHIHOHO**

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]SAGIT Innovation Centre, Harare, Zimbabwe
[3]Independent Researcher, Harare, Zimbabwe

Abstract - **In this research paper, the ANN approach was applied to analyze daily COVID-19deaths in Canada. The employed daily data covers the period to 1 January 2020 to 31 December 2020 and the out-of-sample period ranges over the period to 1January 2021 to 31 May 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting daily COVID-19 cases in Canada. The applied ANN (12, 12, 1) model projections indicate thatCOVID-19 related mortality in Canada is likely to range between 111 and 179 deaths per day over the out-of-sample period. Therefore the government of Canada is encouraged to continue applying WHO guidelines on prevention and control of COVID-19 including COVID-19 vaccination in order to achieve herd immunity.**

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

Artificial intelligence (AI) has overtaken the use of traditional statistical methods in the analysis of public health data (Makridakis, 2017). Many researchers are resorting to machine learning (ML) algorithms to solve classification, regression and time series forecasting problems. ML algorithms can handle complex and nonlinear data unlike traditional methods such as Box-Jenkins ARIMA models which are appropriate for modeling linear data (Robson et al 2017; Salaken et al, 2017; Voyant et al, 2017; Zhang & Suganthan, 2016; Deng, 2014, Hamzacebi et al, 2009; Zhang et al, 1998). ML can be defined as the process where computers learn or understand the nature of the data through the utilization of computer programs. The computer program learns a predictor function or the relationship between variables via a training process. When the algorithm learns the relationship between variables when input and output values are provided it is called supervised learning whereas if the algorithm finds hidden structures in the input data it is referred to as unsupervised learning (Weng et al, 2017). Time series forecasting is critical in public surveillance. It helps in the early detection of disease outbreaks and abnormal patterns of epidemiologic incidences. Artificial neural networks (ANNs), support vector machines (SVM), K-nearest neighbors, tree-based models and graphical models are the widely used machine learning algorithms in time series forecasting ((Nyoni et al, 2020; Zhao et al, 2020;Ahmed et al, 2010; Hastie et al, 2009; Alpaydin, 2004).

In this paper the aim is to model and forecast COVID-19 daily deaths using artificial neural network approach. The Multilayer perceptron (MLP) is utilized in this particular study because of its popularity and reliable results. The model is made up 3 layers of nodes which are the input, hidden and output layer. The model is a supervised learning approach and the back propagation algorithm is used during the training process (Nyoni et al, 2020; Zhao et al, 2020; Arora et al, 2020; Yan et al, 2018; Kolter & Koltun, 2018; Kaushik & Sahi, 2018; Paswan et al, 2018; Ruder, 2017; Fojnica et al, 2016; Quazi et al, 2015; Raghupathi & Raghupathi, 2015; Schmidhuber, 2014; Gomes et al, 2011; Yan et al, 2006; Ozkan et al, 2003; Zhang, 2003; Kishan, 1997; Patterson, 1995). The results of the study are expected to reveal the future trends of COVID-19 mortality in Canada and help facilitate the assessment of COVID-19 prevention and control measures including the COVID-19 vaccination program.

II. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this study; is a data processing system consisting of a huge number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from any data-set to describe the nonlinear and interaction effects with great accuracy. Arguably, explicit guidelines exist for the determination of the ANN structure hence the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function.

Data Issues

This study is based on daily deaths of COVID-19 in Canada for the period 1 January – 31 December 2020. The out-of-sample forecast covers the period January 2021 – May 2021. All the data employed in this paper was gathered from the World Bank.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	F
Observations	354 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.133355
MSE	345.799179
MAE	10.875154

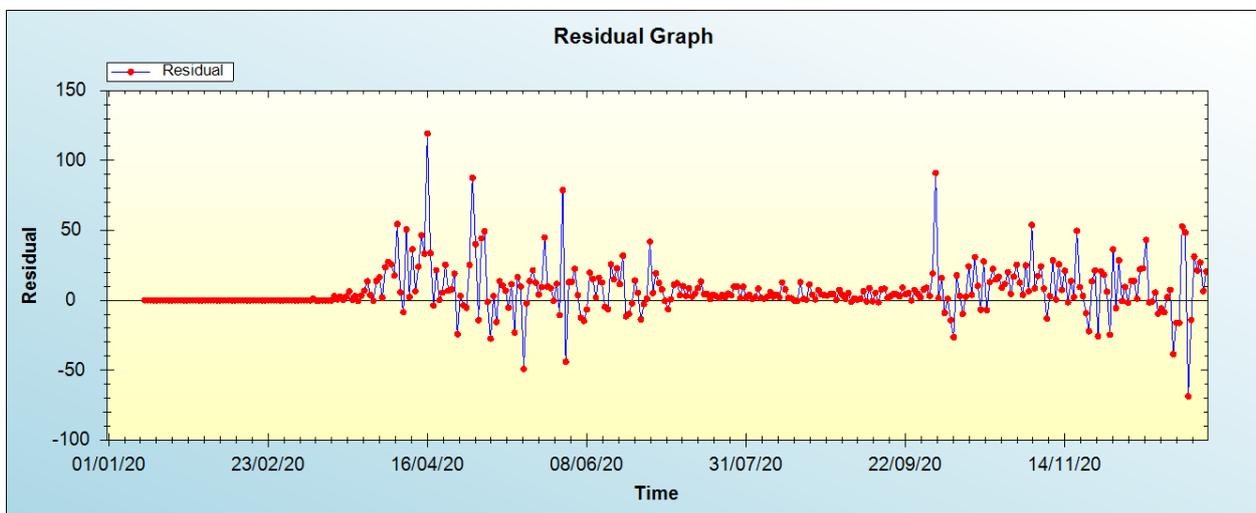*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
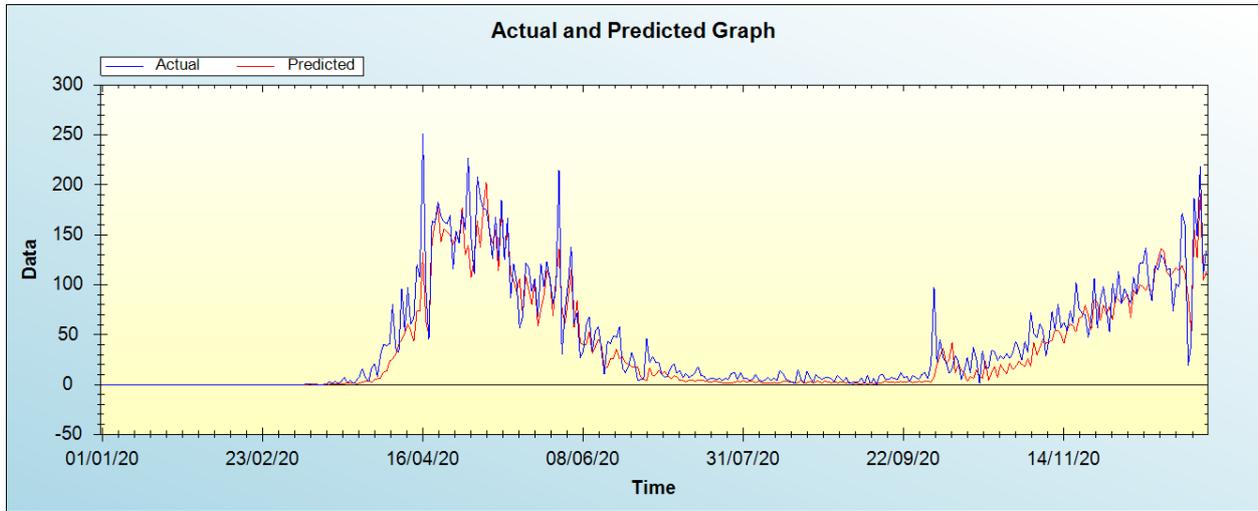
In-sample Forecast for F

Figure 2: In-sample forecast for the F series

Out-of-Sample Forecast for F: Actual and Forecasted Graph
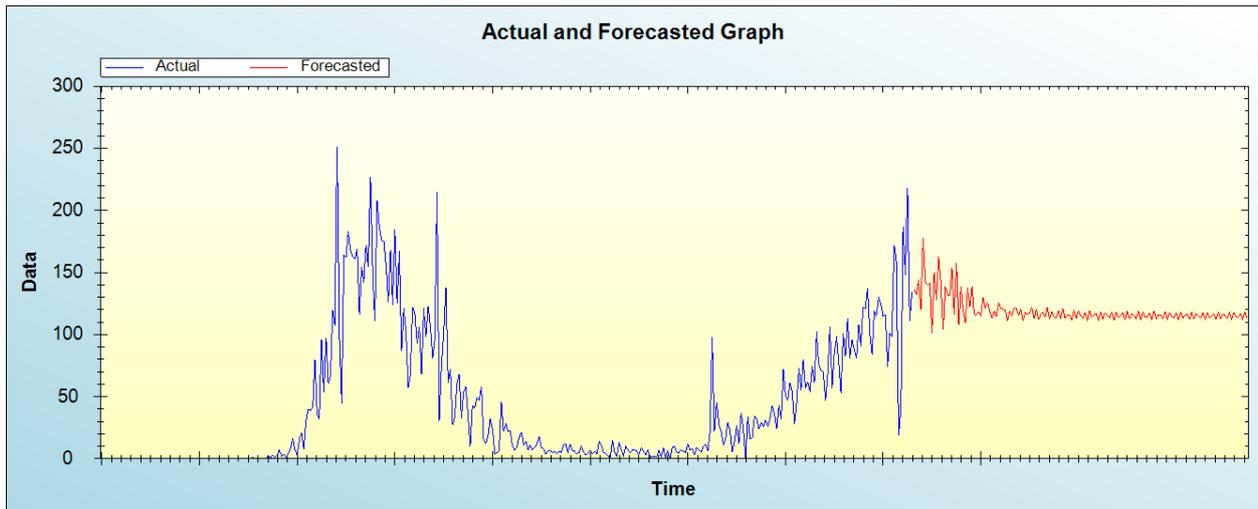

Figure 3: Out-of-sample forecast for F: actual and forecasted graph

Out-of-Sample Forecast for F: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Date	Forecast
01/01/21	136.4848
02/01/21	132.3589
03/01/21	143.4264
04/01/21	119.7031
05/01/21	177.9566
06/01/21	143.1552
07/01/21	139.9473
08/01/21	141.2379
09/01/21	101.1827
10/01/21	149.8062

11/01/21	127.8914
12/01/21	162.4636
13/01/21	142.5790
14/01/21	104.7082
15/01/21	138.8516
16/01/21	131.9632
17/01/21	131.3013
18/01/21	153.9832
19/01/21	116.6719
20/01/21	157.4298
21/01/21	107.4887
22/01/21	138.5078
23/01/21	118.2830
24/01/21	109.6271
25/01/21	137.8326
26/01/21	121.9428
27/01/21	138.4048
28/01/21	116.1384
29/01/21	115.7460
30/01/21	118.5154
31/01/21	115.1146
01/02/21	129.9982
02/02/21	121.1183
03/02/21	125.9444
04/02/21	118.7152
05/02/21	113.1860
06/02/21	119.0589
07/02/21	114.4406
08/02/21	125.5475
09/02/21	120.8961
10/02/21	120.0302
11/02/21	119.6758
12/02/21	111.2405
13/02/21	119.1064
14/02/21	115.0414
15/02/21	121.5633
16/02/21	121.1602
17/02/21	115.3358
18/02/21	120.3319
19/02/21	111.2203
20/02/21	118.1680
21/02/21	116.1995
22/02/21	117.3622
23/02/21	121.7445
24/02/21	112.8467
25/02/21	120.1424
26/02/21	112.2110
27/02/21	115.9954
28/02/21	117.7191
01/03/21	114.1692

02/03/21	121.9469
03/03/21	112.3588
04/03/21	118.5547
05/03/21	113.9177
06/03/21	113.4276
07/03/21	119.1172
08/03/21	112.7194
09/03/21	121.1547
10/03/21	113.2894
11/03/21	115.8283
12/03/21	115.9312
13/03/21	111.7210
14/03/21	119.8375
15/03/21	112.8666
16/03/21	119.0596
17/03/21	115.0023
18/03/21	113.1042
19/03/21	117.6806
20/03/21	111.4117
21/03/21	119.3826
22/03/21	114.0768
23/03/21	116.0845
24/03/21	116.8936
25/03/21	111.5291
26/03/21	118.5600
27/03/21	112.2389
28/03/21	117.5822
29/03/21	115.8146
30/03/21	113.3827
31/03/21	118.3524
01/04/21	111.3857
02/04/21	118.1139
03/04/21	113.7954
04/04/21	115.0130
05/04/21	117.5372
06/04/21	111.9426
07/04/21	118.8177
08/04/21	112.3419
09/04/21	116.3494
10/04/21	115.6669
11/04/21	112.8393
12/04/21	118.6921
13/04/21	111.9196
14/04/21	117.9473
15/04/21	113.9708
16/04/21	114.0360
17/04/21	117.3679
18/04/21	111.8880
19/04/21	118.7962
20/04/21	112.9454

21/04/21	115.9386
22/04/21	115.8267
23/04/21	112.3050
24/04/21	118.3830
25/04/21	112.1849
26/04/21	117.6231
27/04/21	114.5678
28/04/21	113.6827
29/04/21	117.4067
30/04/21	111.7679
01/05/21	118.2891
02/05/21	113.3649
03/05/21	115.5180
04/05/21	116.3132
05/05/21	112.2009
06/05/21	118.2093
07/05/21	112.3327
08/05/21	116.9742
09/05/21	115.0051
10/05/21	113.4167
11/05/21	117.6775
12/05/21	111.9083
13/05/21	117.8707
14/05/21	113.6417
15/05/21	114.9192
16/05/21	116.6465
17/05/21	112.2050
18/05/21	118.1928
19/05/21	112.6302
20/05/21	116.4032
21/05/21	115.2912
22/05/21	113.0714
23/05/21	117.8056
24/05/21	112.1400
25/05/21	117.5731
26/05/21	114.0024
27/05/21	114.4085
28/05/21	116.8314
29/05/21	112.1702
30/05/21	118.0596
31/05/21	112.9948

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that COVID-19 related mortality in Canada is likely to range between 111 and 179 deaths per day over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

The COVID-19 pandemic continues to be a global health problem despite several efforts made by WHO and other international and local organizations in trying to reduce the impact of the deadly virus. The development of several COVID-19 vaccines has brought hope to many people across the globe although there are still concerns over the occurrence of adverse events

following vaccine administration in some individuals. The study results suggests that COVID-19 mortality in Canada is likely to range between 111 and 179 deaths per day from January 1, 2021 to May 31, 2020. The authorities are encouraged to continue enforcing WHO guidelines on prevention and control of COVID-19 including vaccination of people against the deadly virus.

REFERENCES

[1] Bai, S., Kolter, J.Z & Koltun, V. (2018). An Empirical Evaluation of Generic Convolutional and Recurrent Networks for Sequence Modeling. Cornell University Library, arXiv.org, ISSN: 2331-8422, arXiv: 1409.0473.

[2] Dan W. Patterson (1995) Artificial Neural networks Theory and Applications. Singapore; New York: Prentice Hall.

[3] Fojnica, A., Osmanoviae & Badnjeviae A (2016). Dynamic model of tuberculosis-multiple strain prediction based on artificial neural network. In proceedings of the 2016 5th Mediterranean conference on embedded computing pp290-293.

[4] Gomes, G. S. S., et al. (2011). Comparison of New Activation Functions in Neural Network for Forecasting Financial Time Series, Neural Computing & Applications, 20: 417 – 439.

[5] Kaushik AC & Sahi. S (2018). Artificial neural network-based model for orphan GPCRs.Neural.Comput.Appl. 29,985-992.

[6] Kishan Mehrotra., Chilukuri K., Mohan, & Sanjay Ranka (1997) Elements of artificial neural networks. Cambridge, Mass.: MIT Press.

[7] Ozkan, C., & Erbek, F. S. (2003). The Comparison of Activation Functions for Multispectral Landsat TM Image Classification, Photogrammetric Engineering & Remote Sensing, 69 (11): 1225 – 1234.

[8] Paswan, R. P., et al. (2018). Comparison of Abilities of Different Activation Functions of Artificial Neural Networks to Predict Crop Area and Crop Production, International Journal of Pure and Applied Bioscience, 6 (6): 212 – 220.

[9] Qazi, A., Fayaz, H., Wadi, A., Raj, R.G., Rahim, N.A., & Khan, W A (2015). The artificial neural network for solar radiation prediction and designing solar systems: a systematic literature review. Journal of Cleaner Production. 104, 1–12 (2015). https://doi. org/10.1016/j.jclepro.2015.04.041.

[10] Schmidhuber, J. (2014). Deep learning in neural networks: An overview. Neural Networks, 61(2015), pp. 85-117.

[11] Smartson P Nyoni., Thabani Nyoni & Tatenda A Chihoho (2020) Prediction of new Covid-19 cases in Spain using artificial neural networks. IJARIIE Vol-6 Issue-6, 2395-4396.

[12] Smartson P Nyoni., Thabani Nyoni & Tatenda A Chihoho (2020) Prediction of new Covid-19 cases in Ghana using artificial neural networks. IJARIIE Vol-6 Issue-6, 2395-4396.

[13] Smartson. P. Nyoni., Thabani Nyoni & Tatenda A. Chihoho (2020). Forecasting COVID-19 cases in Zimbabwe using artificial neural networks, IJARIIE, 6, 6, 2395-4396.

[14] Smartson. P. Nyoni., Thabani Nyoni & Tatenda A. Chihoho (2020). Forecasting COVID-19 cases in Ethiopia using artificial neural networks, IJARIIE, 6, 6, 2395-4396.

[15] Smartson. P. Nyoni., Thabani Nyoni., Tatenda. A. Chihoho (2020) Prediction of daily new Covid-19 cases in Egypt using artificial neural networks. IJARIIE- Vol-6 Issue-6, 2395-4396.

[16] Weng SF., Reps J., Kai J., Garibaldi JM & Qureshi N (2017) Can machine-learning improve cardiovascular risk prediction using routine clinical data? PLOS ONE 12(4): e0174944. https://doi.org/10.1371/journal.pone.0174944

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