PREDICTION OF COVID-19 CASES IN CANADA USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

The current COVID-19 outbreak is a serious disaster in many parts of the world, including Canada. In this empirical paper, the ANN approach was applied to analyze COVID-19 cases in Canada. The employed data covers the period January 26, 2020 to 31 October, 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is indeed stable in forecasting COVID-19 cases in Canada. The results of the study suggest that daily COVID-19 cases will generally increase until around December 14, where an equilibrium daily case volume of almost 2965 cases will be reached and this daily equilibrium case volume is likely to be persistant through out the rest of the out-of-sample period. The government of Canada should ensure serious compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so on., in line with WHO guidelines. This is very important in controlling further spread of the virus in the country.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

COVID-19 originated in Wuhan, the capital city of China's Hubei province, around December 2019 and spread out all over the world within a few weeks (Chimmula & Zhang, 2020). COVID-19 is a respiratory infectious disease caused by a new strain of coronavirus that causes illness in humans. Scientists are still learning about the disease, and think that the virus began in animals. At some point, one or more humans acquired infection from an animal, and those infected humans began transmitting the infection to other humans. The disease spreads from person to person through infected air droplets that are projected during sneezing or coughing. It can also be transmitted when humans have contact with hands or surfaces that contain the virus and touch their eyes, nose or mouth, with the contaminated hands (Ayinde *et al*., 2020). While most infections with COVID-19 are mild or even asymptomatic, approximately 20% of recognized infections are sufficiently severe to require hospitalization (Wang *et al*., 2020; Guan *et al*., 2020). Among these hospitalized, 10-20% have an intensive care requirement, usually related to respiratory failure (Yang *et al*., 2020; Wang *et al*., 2020; Guan *et al*., 2020), though multiorgan system failure (Zhang *et al*., 2020), clotting abnormalities (Nahum *et al*., 2020) and angioneogenesis (Ackermann *et al*., 2020) with resultant bleeding are increasingly recognized as

severe complications of COVID-19 (Fisman *et al*., 2020). Predicting COVID-19 is important, especially in ensuring that healthcare systems are adequately prepared for the ongoing pandemic (Barrett *et al*., 2020). In Canada, very few studies; for example, Fisman *et al* (2020) and Chimmula & Zhang (2020) have examined the COVID-19 pandemic. Based on LSTM networks, Chimmula and Zhang (2020) forecasted COVID-19 transmission in Canada and predicted that the possible ending point of the pandemic would be around June 2020. Using a Cox Proportional Hazard model, Fisman *et al*. (2020) established that age and cormobidities (especially diabetes, renal disease and immune compromise) were strong predictors of mortality. Given that Chimmula & Zhang (2020)'s forecast, particulary concerning the ending of the pandemic, turned out to be inconsistent with reality and that Fisman *et al*. (2020) did not forecast the future evolution of the pandemic; it has become necessary to come up with a more reliable forecasting model for the analysis of the transmission dynamics of COVID-19 in Canada. The main motive behind this piece of work is to model and forecast COVID-19 cases in Canada using an Artificial Neural Network (ANN) model.

METHODOLOGY

This paper, in line with Chimmula & Zhang (2020); applies a deep learning technique, the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 cases. The study applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. This study is based on daily new Covid-19 cases (referred to as T series in this study) for all age groups in Canada. The data covers the period 26 January 2020 (when the first case was officially reported) to 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this paper was gathered from the COVID-19 data repository prepared by the CSSE at JH University.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
847.55	547.50	0.00000	4111.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
844.22	0.99607	1.3518	1.6567
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	2659.8	1027.0	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN INDIA

Table 2: ANN model summary

Variable	T
Observations	268 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12

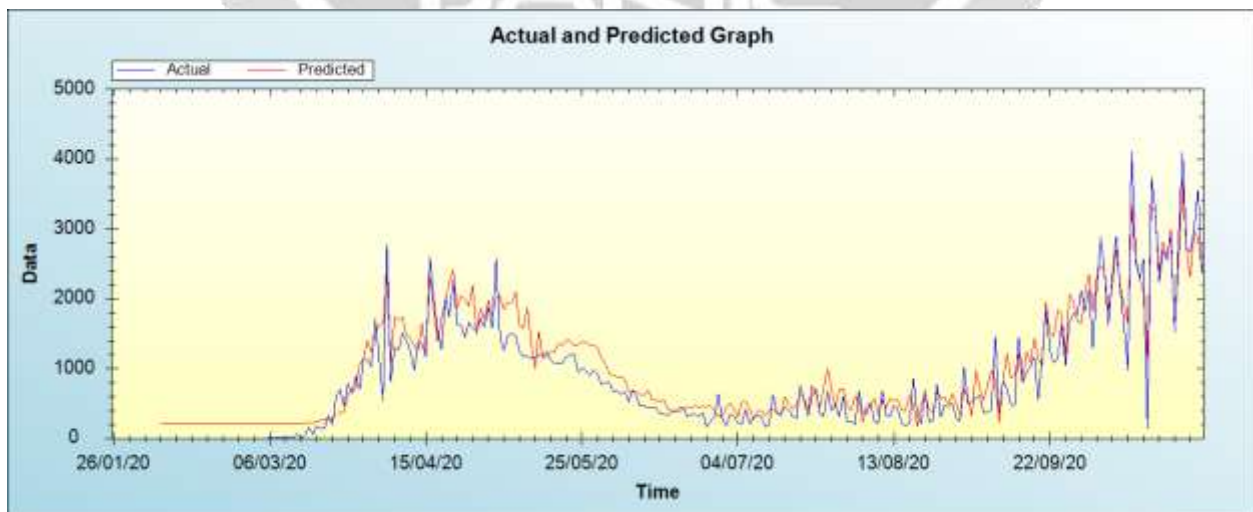| Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.123537
MSE	7606.095762
MAE	225.5844

Residual Analysis for the ANN model
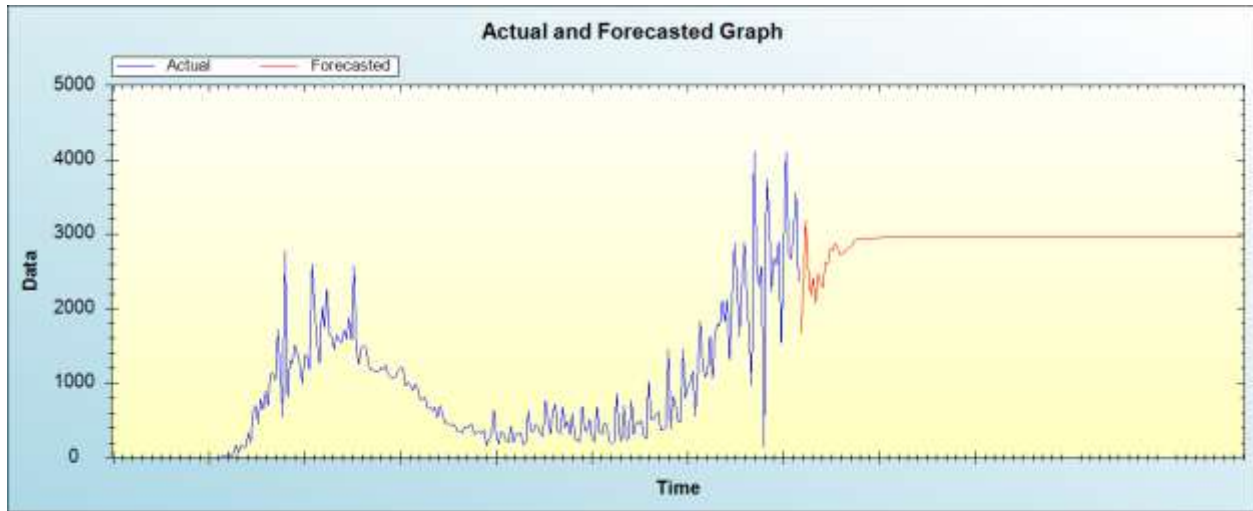
Figure 1: Residual analysis
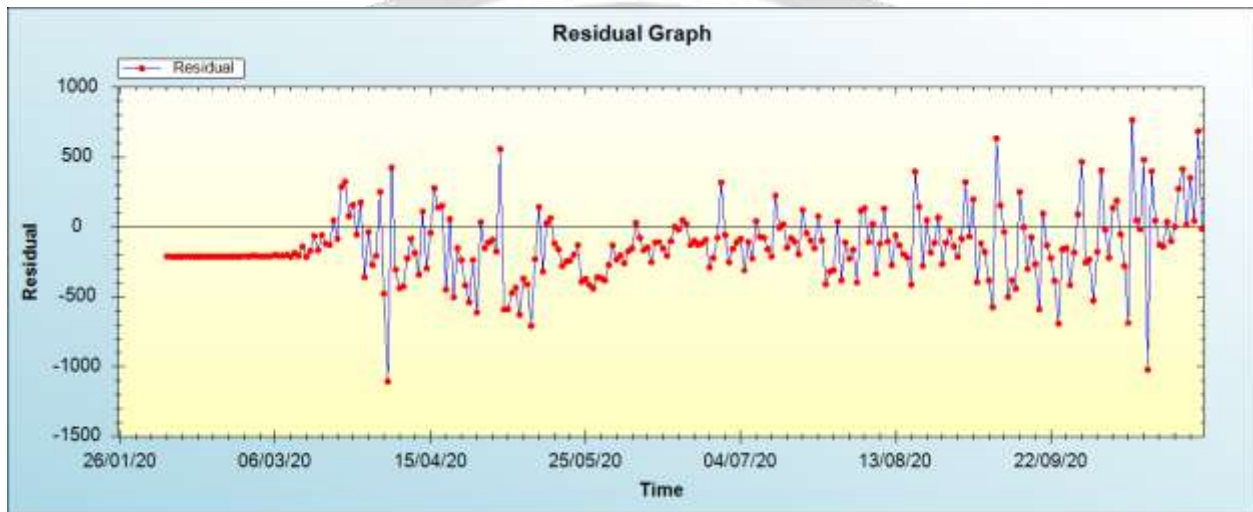
In-sample Forecast for T

Figure 2: In-sample forecast for the T series

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

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

Out-of-Sample Forecast for T: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	1678.0619
02/11/20	2273.0810
03/11/20	3188.2946
04/11/20	2534.6174
05/11/20	2181.5947
06/11/20	2405.2804
07/11/20	2070.8862
08/11/20	2480.2958
09/11/20	2339.1231
10/11/20	2285.7004
11/11/20	2624.4381
12/11/20	2600.6783
13/11/20	2809.5253
14/11/20	2784.3399

15/11/20	2875.2503
16/11/20	2808.2150
17/11/20	2725.0280
18/11/20	2741.5872
19/11/20	2762.3568
20/11/20	2808.8042
21/11/20	2824.8731
22/11/20	2856.0941
23/11/20	2919.1187
24/11/20	2933.8118
25/11/20	2939.1446
26/11/20	2938.9373
27/11/20	2945.2935
28/11/20	2946.8960
29/11/20	2937.0076
30/11/20	2936.4060
01/12/20	2946.5819
02/12/20	2953.1250
03/12/20	2955.2714
04/12/20	2956.1349
05/12/20	2961.0644
06/12/20	2964.9133
07/12/20	2963.8394
08/12/20	2962.2979
09/12/20	2963.1119
10/12/20	2964.4000

11/12/20	2964.1692
12/12/20	2963.1818
13/12/20	2963.6975
14/12/20	2964.8951
15/12/20	2965.0972
16/12/20	2964.6772
17/12/20	2964.7369
18/12/20	2965.2749
19/12/20	2965.4284
20/12/20	2965.0828
21/12/20	2964.9662
22/12/20	2965.2100
23/12/20	2965.3413
24/12/20	2965.2012
25/12/20	2965.1027
26/12/20	2965.2246
27/12/20	2965.3388
28/12/20	2965.2816
29/12/20	2965.2071
30/12/20	2965.2481
31/12/20	2965.3154
01/01/21	2965.2972
02/01/21	2965.2453
03/01/21	2965.2539
04/01/21	2965.2946
05/01/21	2965.2947

06/01/21	2965.2663
07/01/21	2965.2637
08/01/21	2965.2861
09/01/21	2965.2920
10/01/21	2965.2768
11/01/21	2965.2710
12/01/21	2965.2818
13/01/21	2965.2877
14/01/21	2965.2806
15/01/21	2965.2753
16/01/21	2965.2800
17/01/21	2965.2847
18/01/21	2965.2819
19/01/21	2965.2781
20/01/21	2965.2798
21/01/21	2965.2829
22/01/21	2965.2821
23/01/21	2965.2797
24/01/21	2965.2800
25/01/21	2965.2818
26/01/21	2965.2818
27/01/21	2965.2805
28/01/21	2965.2803
29/01/21	2965.2813
30/01/21	2965.2816
31/01/21	2965.2809

01/02/21	2965.2806
02/02/21	2965.2811
03/02/21	2965.2813
04/02/21	2965.2810
05/02/21	2965.2808
06/02/21	2965.2810
07/02/21	2965.2812
08/02/21	2965.2811
09/02/21	2965.2809
10/02/21	2965.2810
11/02/21	2965.2811
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27/04/21	2965.2810
28/04/21	2965.2810
29/04/21	2965.2810
30/04/21	2965.2810

The descriptive statistics, summary of the applied deep learning model, residual analysis, in-sample forecasts as well as out-of-sample forecasts are shown in table 1, table 2, figure 1, figure 2 and well as figure 3 and table 3, respectively. The results of the study show that daily COVID-19 cases will generally increase until around December 14, where an equilibrium daily case volume of approximately 2965 cases will be reached and this daily equilibrium case volume is likely to be persistant through out the rest of the out-of-sample period. Unlike Chimmula & Zhang (2020) who predicted that the pandemic would end around June 2020, our results warn us that the pandemic will actually not end any time soon in Canada.

CONCLUSION & RECOMMENDATIONS

COVID-19 is still spreading rapidly in many countries around the world. Based on 280 daily observations of COVID-19 cases in Canada, this study used the ANN (12, 12, 1) model to come up with predictions ranging over the period November 2020 to April 2021. The results of the study show that the COVID-19 pandemic will not end anytime soon in the country. The country should ensure serious compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so on., in line with WHO guidelines.

REFERENCES

[1] Ackermann, M., *et al*. (2020). Pulmonary Vascular Endothelialitis, Thrombosis and Angiogenesis in COVID-19, *New England Journal of Medicine*, pp: 1 – 11.

[2] Ayinde, K., *et al*. (2020). Modeling Nigerian COVID-19 Cases: A Comparative Analysis of Models and Estimators, *Chaos, Solitons and Fractals*, 138 (2020): 1 – 17.

[3] Barret, K., *et al*. (2020). Estimation of COVID-19-induced Depletion of Hospital Resources in Ontario, Canada, *CMAJ*, pp: 1 – 7.

[4] Chimmula, V. K. R., & Zhang, L. (2020). Time Series Forecasting of COVID-19 Transmission in Canada Using LSTM Networks, *Chaos, Solitons and Fractals*, 135 (2020): 1 – 6.

[5] COVID-19 Repository By the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

[6] Dong, E., *et al*. (2020). An Interactive Web-based Dashboard to Track COVID-19 in Real Time, *Lancet Infectious Diseases*, 20 (5): 533 – 534.

[7] Fisman, D. N., *et al*. (2020). Derivation and Validation of Clinical Prediction Rule for COVID-19 Mortality in Ontario, Canada, *medRxiv*, pp: 1 – 50.

[8] Guan, W. J., *et al*. (2020). Clinical Characteristics of Coronavirus Disease 2019 in China, *New England Journal of Medicine*, pp: 1 – 6.

[9] Nahum, J., *et al*. (2020). Venous Thrombosis Among Critically ill Patients With Coronavirus Disease 2019 (COVID-19), *JAMA*, 3 (5): 1 – 7.

[10]   Wang, D., *et al*. (2020). Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-infected Pneumonia in Wuhan, China, *JAMA*, pp: 1 – 9.

[11]   Yang, X., *et al*. (2020). Clinical Course and Outcomes of Critically ill Patients With SARS-CoV-2 Pneumonia in Wuhan, China: A Single-centered, Retrospective, Observational Study, *Lancet – Respiratory Medicine*, 8 (5): 475 – 481.

[12]   Zhang, C., *et al*. (2020). Cytokine Release Syndrome in Severe COVID-19: Interleukin-6 Receptor Antagonist Tocilizumab may be the Key to Reduce Mortality, *International Journal of Antimicrobic Agents*, 55 (5): 1 – 16.