

Forecasting Daily Covid-19 Cases in Botswana Using Artificial Neural Networks

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Abstract - In this research paper, the ANN approach was applied to analyze daily new COVID-19 cases in Botswana. 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 1 January 2020 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 new COVID-19 cases in Botswana. The applied ANN (12, 12, 1) model projections indicate that daily COVID-19 case volume will generally be in the range 0-1400 cases over the period 1 January 2021 to 31 May 2021. Therefore the government of Botswana is encouraged to continue applying WHO guidelines on prevention and control of COVID-19 including vaccinating 60 % of the population in order to achieve herd immunity.

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

On the 11th of March 2020, WHO declared SARS-CoV 2 as a global pandemic and this time there were 118 000 reported cases in 114 countries with above 4000 fatalities. The COVID-19 virus was spreading very at alarming rate with 3.6 million infected people as of 6 May 2020 (UNECA, 2020). In the SADC region, South Africa, Tanzania and Mauritius reported most cases and fatalities due to COVID-19 (UN, 2020). Botswana reported its first case of COVID-19 on the 30th of March 2020 (UN, 2020). The country’s initial response to the pandemic was commendable. The government ordered the closure of its borders on the 24th of March 2020, a national lockdown came into force on the 2nd of April 2020. Its strategy to curb the spread of the epidemic included social distancing, isolation and quarantining of cases, quality clinical care of COVID-19 patients, contact tracing and testing, and restricted movement of people. The objective of this study is to model and predict daily new COVID-19 cases in Botswana using the multilayer perceptron (MLP). The neural network approach is based on the structure and function of the human brain. The model is a feed forward neural network composed of 3 layers of neurons namely input, hidden and output layers connected by connection weights (Nyoni et al,2020; Zhao et al, 2020; Arora et al, 2020; Yan et al, 2018; Kolter & Koltun, 2018; Kaushik & Sahi, 2018; Ruder, 2017; Fojnica et al, 2016;Quazi et al, 2015; Raghupathi & Raghupathi, 2015; Schmidhuber, 2014; Yan et al, 2006; Zhang, 2003; Kishan, 1997; Patterson, 1995). The results of this piece of work are expected to reveal the future trends of daily new COVID-19 cases in Botswana and facilitate planning and stimulate a national response to the COVID-19 epidemic.

II. LITERATURE REVIEW

Table 1: Literature Review

Author (s)	Study period	Method	Findings
Nyoni et al (2020)	14March 2020 to 31October 2020	ANN model	COVID-19 virus would be under control in Ghana (around zero daily new covid-19 cases are projected) from November 2020 to April 2021
Wiah et al (2020)	23May 2020 to 24April 2020	SEIRQT Model	Early quarantine and high quarantine rate are vital in

			the control of COVID-19
Gyilbag et al (2020)	29Feb 2020 to 23June 2020	Holt's Exponential smoothing model (HES)	The cumulative case count in Ghana is predicted to be 14086 by 23 December 2020. Many activities associated with the electoral cycle could exacerbate the cumulative cases in Ghana and neighboring countries.
Saba & Elsheikh (2020)	1 March 2020 to 10 May 2020	ARIMA, NARANN	Forecasted cases showed a good agreement with officially reported cases.

III. METHODOLOGY

The Artificial Neural Network (ANN) will be applied in this study. 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 new cases of COVID-19 in Botswana 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.

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 2: ANN model summary

Variable	Q
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	2.564203
MSE	16096.999881
MAE	102.803279

Residual Analysis for the Applied Model

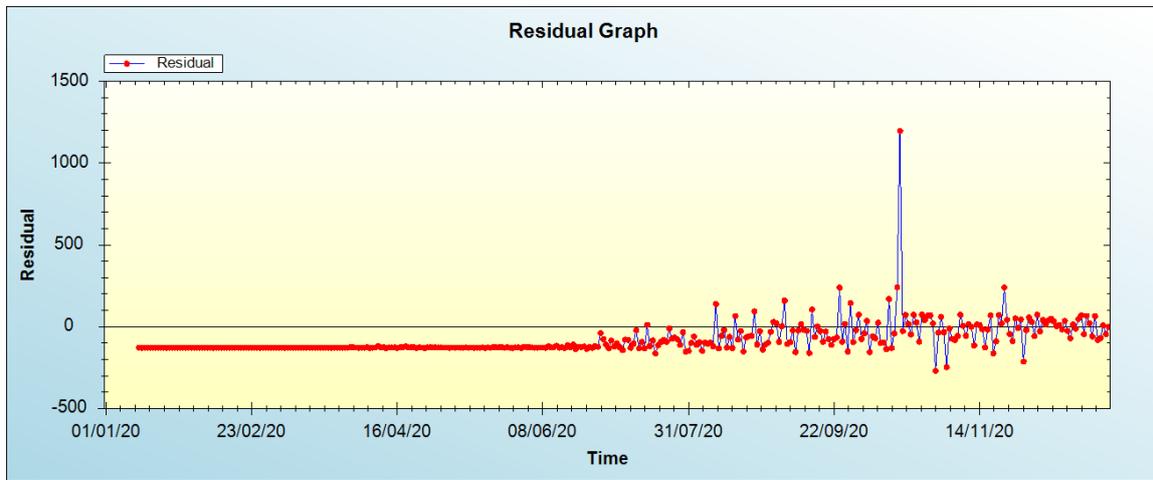


Figure 1: Residual analysis

In-sample Forecast for Q

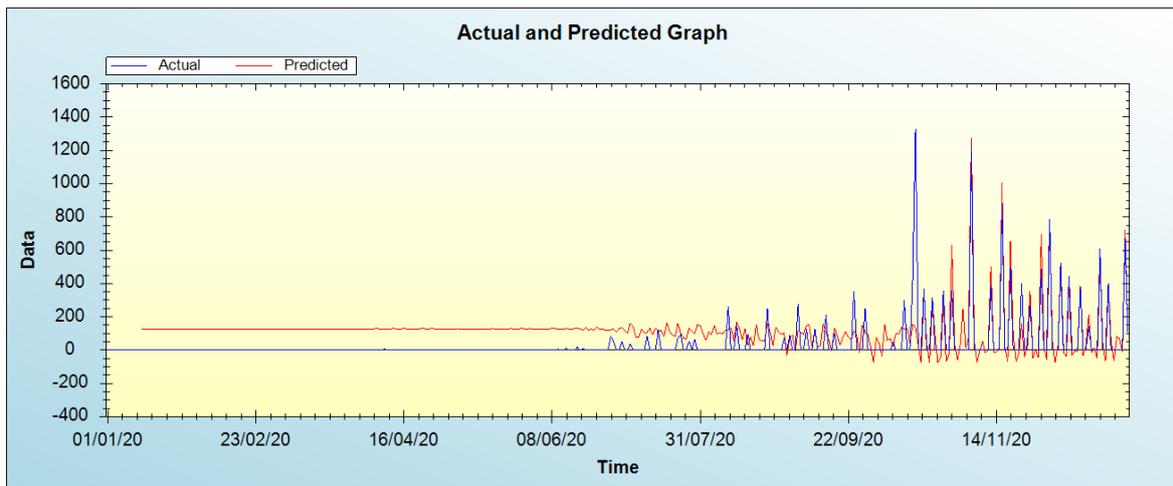


Figure 2: In-sample forecast for the Q series

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

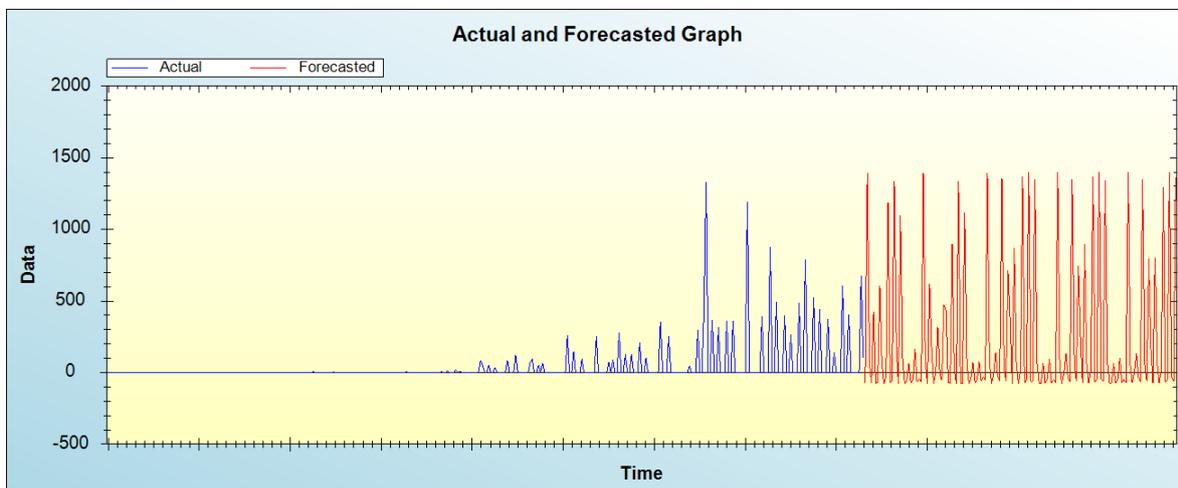


Figure 3: Out-of-sample forecast for Q: actual and forecasted graph

Out-of-Sample Forecast for Q: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasted daily COVID-19 cases
01/01/21	-72.7979
02/01/21	1392.7585
03/01/21	61.1267
04/01/21	-73.7620
05/01/21	421.8598
06/01/21	-73.1551
07/01/21	-69.9078
08/01/21	608.1478
09/01/21	79.4845
10/01/21	-73.7488
11/01/21	-25.0588
12/01/21	1186.6130
13/01/21	-72.6194
14/01/21	-55.7787
15/01/21	1338.1311
16/01/21	153.7930
17/01/21	-72.7572
18/01/21	1094.8767
19/01/21	70.3696
20/01/21	-73.7747
21/01/21	-63.9240
22/01/21	67.4910
23/01/21	-71.6592
24/01/21	-51.2092
25/01/21	168.9402
26/01/21	-66.7779
27/01/21	-43.0233
28/01/21	-64.2573

29/01/21	1390.7539
30/01/21	70.4633
31/01/21	-73.6708
01/02/21	619.9156
02/02/21	154.1030
03/02/21	-73.3627
04/02/21	2.4449
05/02/21	317.1125
06/02/21	-21.1204
07/02/21	-51.0407
08/02/21	475.1258
09/02/21	433.4258
10/02/21	-71.6280
11/02/21	-72.3355
12/02/21	899.3356
13/02/21	18.0144
14/02/21	-73.6474
15/02/21	1336.4109
16/02/21	-73.2496
17/02/21	-73.7711
18/02/21	1114.4638
19/02/21	72.5416
20/02/21	-73.7730
21/02/21	-49.2857
22/02/21	71.0196
23/02/21	-73.7227
24/02/21	-51.5182
25/02/21	80.5563
26/02/21	-58.8620
27/02/21	-30.4771
28/02/21	-51.2176

01/03/21	1394.0056
02/03/21	67.9659
03/03/21	-73.6658
04/03/21	-18.0270
05/03/21	139.5910
06/03/21	-20.7047
07/03/21	-60.4498
08/03/21	1356.3972
09/03/21	47.8614
10/03/21	-57.9260
11/03/21	715.2791
12/03/21	369.8536
13/03/21	-73.7285
14/03/21	872.9393
15/03/21	75.5843
16/03/21	-73.7319
17/03/21	10.9568
18/03/21	1370.0150
19/03/21	-73.4896
20/03/21	-48.1959
21/03/21	1400.3048
22/03/21	-61.6438
23/03/21	-59.6172
24/03/21	1346.9121
25/03/21	67.3515
26/03/21	-73.7753
27/03/21	-73.2324
28/03/21	65.7538
29/03/21	-73.7639
30/03/21	-44.1478
31/03/21	98.0142

01/04/21	-70.5084
02/04/21	-49.0456
03/04/21	-67.5858
04/04/21	1399.4957
05/04/21	56.1497
06/04/21	-73.6262
07/04/21	-7.0620
08/04/21	132.7238
09/04/21	-36.1793
10/04/21	-62.7552
11/04/21	1350.9928
12/04/21	59.2452
13/04/21	-57.8256
14/04/21	745.9448
15/04/21	261.8170
16/04/21	-73.7473
17/04/21	891.4664
18/04/21	73.2489
19/04/21	-73.7225
20/04/21	20.8641
21/04/21	1368.8170
22/04/21	-68.1931
23/04/21	-45.6646
24/04/21	1400.1592
25/04/21	-49.3842
26/04/21	-59.4338
27/04/21	1341.9065
28/04/21	67.2481
29/04/21	-73.7752
30/04/21	-73.2396
01/05/21	65.6042

02/05/21	-73.7627
03/05/21	-44.1709
04/05/21	101.3842
05/05/21	-70.8064
06/05/21	-49.1389
07/05/21	-67.4917
08/05/21	1399.3533
09/05/21	56.2875
10/05/21	-73.6269
11/05/21	-0.6917
12/05/21	132.4862
13/05/21	-38.0040
14/05/21	-62.7167
15/05/21	1349.3657
16/05/21	59.6659
17/05/21	-57.8249
18/05/21	790.7107
19/05/21	187.1367
20/05/21	-73.7553
21/05/21	800.6109
22/05/21	73.0732
23/05/21	-73.6861
24/05/21	12.6724
25/05/21	1288.1841
26/05/21	-64.0446
27/05/21	-49.1732
28/05/21	1399.3615
29/05/21	-27.3506
30/05/21	-59.8675
31/05/21	1358.2709

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 daily COVID-19 case volume will generally be in the range 0-1400 cases over the period 1 January 2021 to 31 May 2021.

V. CONCLUSION & RECOMMENDATIONS

The COVID-19 virus was detected in Wuhan City, Hubei Province of China and spread around the globe in a short space of time. The pandemic is regarded as one of the troublesome and deadliest pandemics to affect the inhabitants of the earth (Anadolu agency, 2020; Toit, 2020). The characteristic of the pandemic are changing every day, this includes morbidity, mortality rates and the emergence of new strains which have potential disastrous consequences to the human beings. Different countries were affected by the pandemic at different time intervals and the intensity of their responses to the virus have been different. Botswana as one of the SADC states responded promptly to the pandemic and the government has managed to minimize the impact of the pandemic on its citizens in terms of morbidity and mortality rates. The results of this paper indicate that daily COVID-19 case volume will generally be in the range 0-1400 cases over the period 1 January 2021 to 31 May 2021. Therefore the government must continue practicing social distancing, regular hand washing, wearing face masks, isolation & quarantining of cases, contact tracing, treatment of cases and vaccination of its people.

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