PREDICTION OF COVID-19 CASES IN SOUTH AFRICA USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

The outbreak of COVID-19 is indeed a public health emergency of international concern. Governments, researchers and healthcare professionals of various disciplines are addressing the problem of controlling the spread of the virus while reducing the negative effect on the economy and society. In this research article, the ANN approach was applied to analyze COVID-19 cases in South Africa. The employed data covers the period March 5, 2020 to October 31, 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 basic ANN model indicate that the model is stable. Our results suggest that daily COVID-19 cases are generally decreasing. We encourage the government of South Africa to continue enforcing control and preventive measures in line with the World Health Organization (WHO).

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

INTRODUCTION

COVID-19, known to have originated from Wuhan city in Hubei Province in China, is caused by a novel coronavirus, widely recognized as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Ng *et al*., 2020). Being declared by WHO as a pandemic, the novel coronavirus is now a major emergency worldwide (Haghanifar *et al*., 2020). The virus is transmitted from one person to another by respiratory droplets or close contact with a contaminated surface (WHO, 2020). The most common symptoms are fever, cough, and dyspnea, which may appear 2 – 14 days after exposure to virus (Kanne *et al*., 2020). The first case of COVID-19 in South Africa was officially confirmed on March 5, 2020 (South African Government, 2020). In an attempt to contain the epidemic, a national lockdown was declared on March 26, 2020. The majority of confirmed cases early in the outbreak were linked to international travel (NICD, 2020), later on; local transmission set its foot heavily: for example, the cases in the Free State province have mainly been attributed to a cluster transmission as a result of a mega church gathering (Haffajee, 2020). Optimal decision making in the context of COVID-19 pandemic is a complex process (Alamo *et al*., 2020) that requires the use of reliable predictive models such as Artificial Neural Network (ANN) models. In fact, in a state of pandemic, the ability to accurate forecast caseload is extremely important to help inform policy makers on how to allocate limited healthcare resources, rapidly control the outbreak and ensure the safety of the general public

(Kapoor *et al*., 2020; Li *et al*., 2020). For decision makers in South Africa, one of the biggest challenges posed by the virus is how the pandemic will behave in the coming months. This study seeks to model and forecast COVID-19 cases in South Africa using a basic ANN model.

METHODOLOGY

Several outbreak prediction models for COVID-19 are being used by officials around the world to make informed decisions and enforce relevant control measures (Ardabili *et al*., 2020). This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in South Africa. This study particularly employs the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. The paper is based on daily new covid-19 cases (referred to as B series in this study) for all age groups in the Republic of South Africa. The data covers the period 5 March 2020 to 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this research paper was gathered from John Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
3010.2	1736.0	0.00000	13944.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
3663.2	1.2170	1.5757	1.4279
5% Perc.	95% Perc.	IQ range	Missing obs.
13.100	12189.	3404.5	0

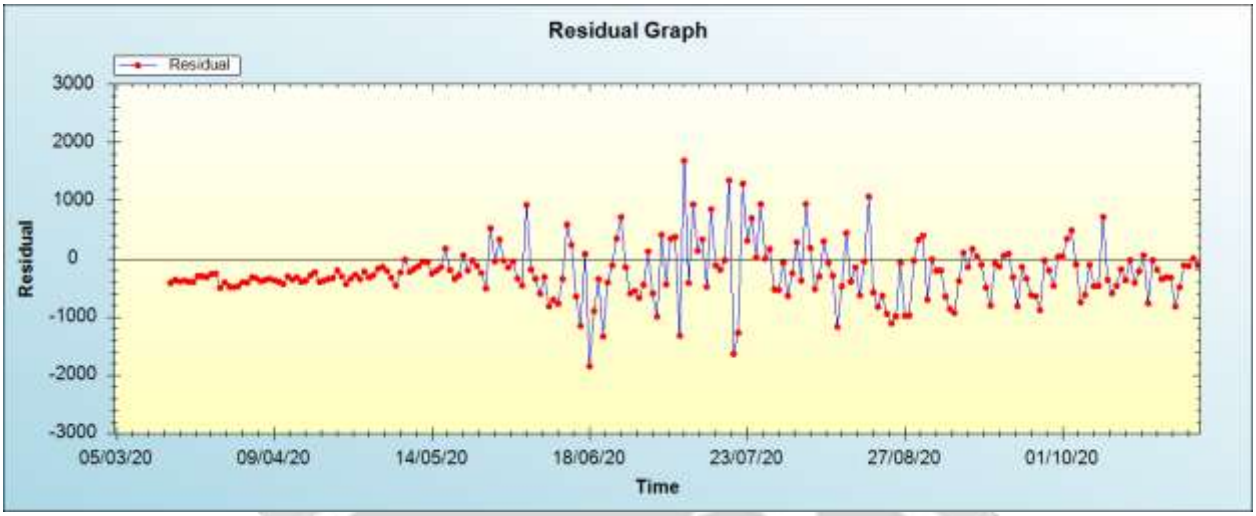
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN SOUTH AFRICA

Table 2: ANN model summary

Variable	B
Observations	22 (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	0.068306
MSE	279990.029059
MAE	414.465502

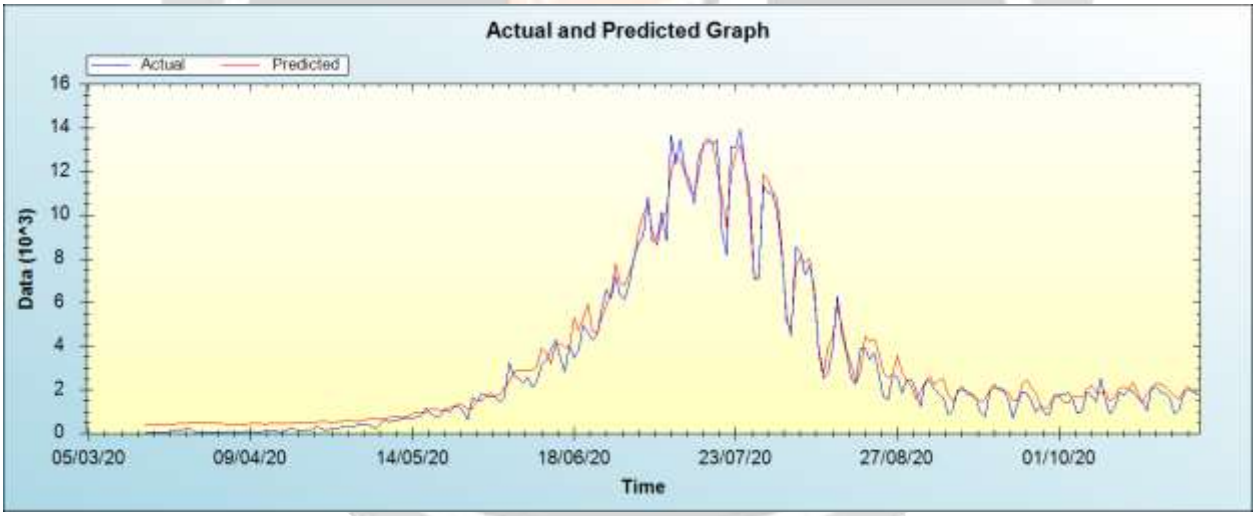
Residual Analysis for the ANN model

Figure 1: Residual analysis



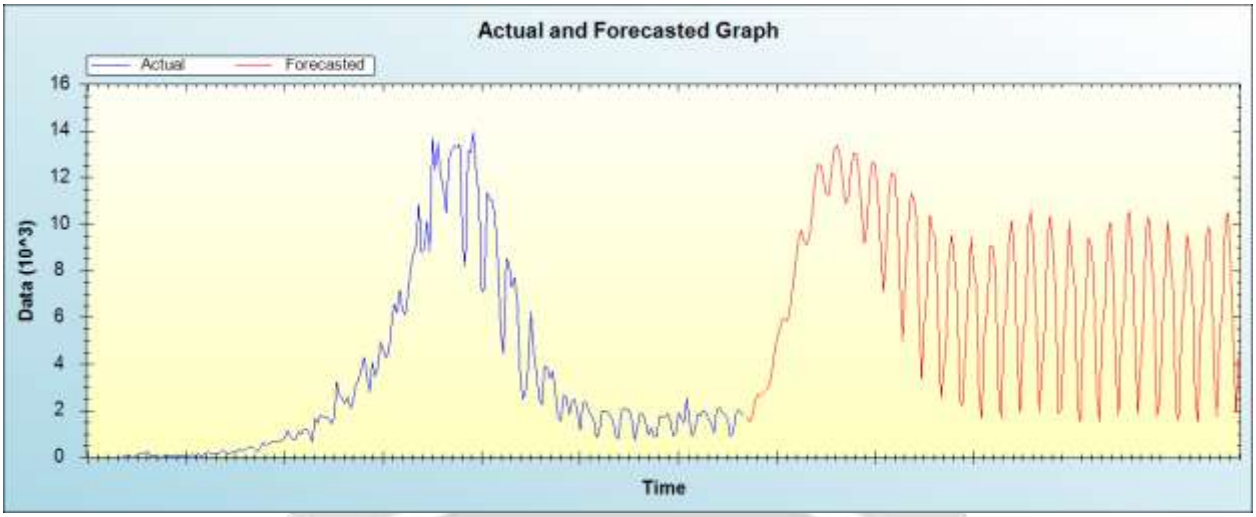
In-sample Forecast for B

Figure 2: In-sample forecast for the B series



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

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



Out-of-Sample Forecast for B: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	1735.9674
02/11/20	1519.0812
03/11/20	1759.8248
04/11/20	2436.7452
05/11/20	2710.3430
06/11/20	2649.9829
07/11/20	2767.8852
08/11/20	2887.7459
09/11/20	3012.9447
10/11/20	3495.2551
11/11/20	4408.1102
12/11/20	5067.3038
13/11/20	5498.9625
14/11/20	5945.1551
15/11/20	5882.3998

16/11/20	5910.2242
17/11/20	6572.4969
18/11/20	7503.4752
19/11/20	8473.0567
20/11/20	9384.7833
21/11/20	9726.7572
22/11/20	9273.8176
23/11/20	9112.4717
24/11/20	9522.9345
25/11/20	10560.0770
26/11/20	11925.5679
27/11/20	12572.3358
28/11/20	12544.5322
29/11/20	11992.9715
30/11/20	11287.7902
01/12/20	11251.8035
02/12/20	12316.8569
03/12/20	13160.1436
04/12/20	13386.3647
05/12/20	12995.2254
06/12/20	12021.9740
07/12/20	10893.4549
08/12/20	11004.0403
09/12/20	12301.6715
10/12/20	13056.6710
11/12/20	13035.1928

12/12/20	12174.3902
13/12/20	10627.0825
14/12/20	9184.3231
15/12/20	9981.8438
16/12/20	11921.2439
17/12/20	12689.4036
18/12/20	12530.0174
19/12/20	11309.4708
20/12/20	8989.1397
21/12/20	7079.4942
22/12/20	8991.0571
23/12/20	11394.6025
24/12/20	12188.4563
25/12/20	12131.7446
26/12/20	10790.5850
27/12/20	7370.3355
28/12/20	5005.4360
29/12/20	7785.7413
30/12/20	9906.3970
31/12/20	11325.8960
01/01/21	11158.3127
02/01/21	10307.9614
03/01/21	6189.6366
04/01/21	3354.2437
05/01/21	5855.7535
06/01/21	7249.6995

07/01/21	10386.9875
08/01/21	9643.1455
09/01/21	9454.0704
10/01/21	6031.8127
11/01/21	2552.8072
12/01/21	3667.9791
13/01/21	5203.3995
14/01/21	8654.2347
15/01/21	9532.4451
16/01/21	8384.8180
17/01/21	6693.9473
18/01/21	2423.5115
19/01/21	2209.8617
20/01/21	4847.3564
21/01/21	6981.5081
22/01/21	9443.1122
23/01/21	8022.4289
24/01/21	7366.6542
25/01/21	2597.4172
26/01/21	1690.1613
27/01/21	5259.7305
28/01/21	6525.8029
29/01/21	9048.1072
30/01/21	9077.3039
31/01/21	7989.2030
01/02/21	3115.2692

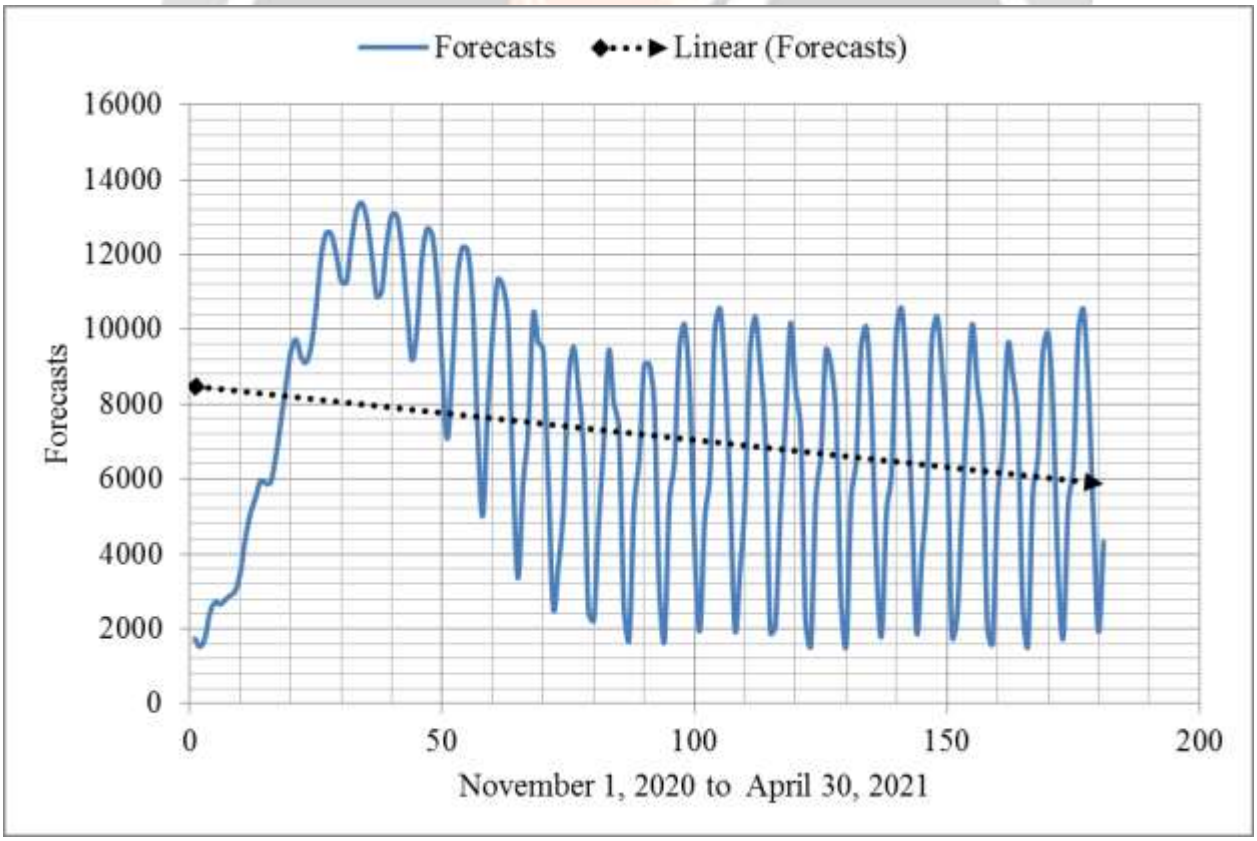
02/02/21	1660.2741
03/02/21	5412.7620
04/02/21	6456.0797
05/02/21	9515.5236
06/02/21	10137.4445
07/02/21	8377.3529
08/02/21	4175.8714
09/02/21	1942.7268
10/02/21	4939.9223
11/02/21	6095.5052
12/02/21	9975.2644
13/02/21	10564.3728
14/02/21	8852.6498
15/02/21	5732.2443
16/02/21	1962.8910
17/02/21	3577.6063
18/02/21	5520.5962
19/02/21	9477.1582
20/02/21	10333.1646
21/02/21	9016.1751
22/02/21	7065.1548
23/02/21	1889.5831
24/02/21	2074.9021
25/02/21	5193.4125
26/02/21	7586.0666
27/02/21	10166.9964

28/02/21	8383.1146
01/03/21	7315.2316
02/03/21	2187.6929
03/03/21	1534.4291
04/03/21	5474.8256
05/03/21	6631.1948
06/03/21	9434.8198
07/03/21	9048.1038
08/03/21	7663.7072
09/03/21	2760.4605
10/03/21	1533.5832
11/03/21	5502.1497
12/03/21	6467.1204
13/03/21	9553.1807
14/03/21	10065.9119
15/03/21	7988.0035
16/03/21	3835.4257
17/03/21	1799.3494
18/03/21	5115.1025
19/03/21	6170.3504
20/03/21	9964.0244
21/03/21	10568.6661
22/03/21	8568.7392
23/03/21	5324.2742
24/03/21	1876.0008
25/03/21	3907.1419

26/03/21	5689.3375
27/03/21	9732.6595
28/03/21	10342.5395
29/03/21	8968.9153
30/03/21	6775.2220
31/03/21	1798.3839
01/04/21	2363.4490
02/04/21	5271.2909
03/04/21	8066.7842
04/04/21	10142.7333
05/04/21	8499.1236
06/04/21	7217.6362
07/04/21	2027.2099
08/04/21	1591.3866
09/04/21	5448.8585
10/04/21	6744.0724
11/04/21	9576.0165
12/04/21	8794.6682
13/04/21	7489.6361
14/04/21	2548.1018
15/04/21	1541.0917
16/04/21	5609.7797
17/04/21	6539.0174
18/04/21	9412.3378
19/04/21	9899.1619
20/04/21	7861.3251

21/04/21	3512.2572
22/04/21	1756.5344
23/04/21	5322.6752
24/04/21	6285.5918
25/04/21	9911.9427
26/04/21	10545.1674
27/04/21	8376.7761
28/04/21	4924.3810
29/04/21	1919.8424
30/04/21	4316.1105

Figure 4: Graphical presentation of out-of-sample forecasts



Since the confirmation of first case of COVID-19 in South Africa, cases have generally continued to rise in the country, at first exponentially and then later on gradually. Table 1 shows that the maximum number of daily cases over the period under study is 13944 cases. Table 2 presents the ANN (12, 12, 1) model, which has been shown to be generally stable as indicated in figure 1. Figure 2 is an in-sample forecast while figures 3 and 4 as well as table 3 present out-of-

sample forecasts. It is clear that the daily COVID-19 cases are now on a downwards trajectory in South Africa even though the pandemic is far from ending in the country.

CONCLUSION & RECOMMENDATIONS

Access to accurate outbreak prediction models is essential to obtain insights into the likely spread and consequences of infectious diseases. Governments and other legislative bodies rely on insights from prediction models to suggest new policies and to assess the effectiveness of the enforced policies (Remuzzi & Remuzzi, 2020). Therefore, in order to prepare, understand and control the spread of the disease, researchers worldwide have come together in a collaborative effort to model and forecast COVID-19 (Kapoor *et al*., 2020). Consistently, in this work, we use a generalized ANN (12, 12, 1) model to analyze daily COVID-19 cases in South Africa. Our results show that daily COVID-19 cases are generally decreasing. We encourage the government of South Africa to continue enforcing control and preventive measures suggested by WHO, for example, face-mask wearing, social distancing, isolations, quarantine and so on. This will go a long way in ensuring a consistent downwards trends of daily COVID-19 cases in the country.

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