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Modelling and Forecasting Covid-19 Fatalities in South Africa using Artificial Neural Networks (ANN)

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 deaths in South Africa. The employed data covers the period January – December 2020 and the out-of-sample period ranges over the period January – May 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is quite stable. The results of the study indicate that that COVID-19 mortality in South Africa will basically range between 100 and 300 deaths per day over the out-of-sample period. Amongst other suggested policy directions, there is need for the government of South Africa to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic.**

Keywords: Artificial Neural Networks, ANN.

I. INTRODUCTION

Over the years focus had shifted from infectious to non-infectious diseases and large public health interventions had been focused on alleviating non communicable diseases that are weight and stress related. However, since the inception of the COVID-19 outbreak in 2019 infectious diseases have now again become prominent and are infecting global populations and causing high volume death rates. COVID-19 is a respiratory infections illness triggered by a new strain of corona virus that causes illness in people. Ongoing research suggests that the virus may have come from animals and those infected humans began transmitting the infection to other humans. The disease is airborne and air droplets projected during sneezing and coughing spread the virus. Other means including touching surfaces that contain the virus and later touch their eyes, nose or mouth (Ayinde et al., 2020). The World Health Organization (WHO) declared the virus a global pandemic on 11 March 2020 and since then the virus has reached most nations on the continent, South Africa included. In South Africa the first case of COVID-19, was reported on March 5, 2020, and as of 10:05 a.m. CEST,17 March, 2021, there have been 1 530 966 confirmed infections and 51 560coronavirus related deaths, (WHO Dashboard 2020). Lockdown restrictions were enforced to help curb the spread of the virus and these have since been relaxed to enable economic activities and help bring a balance between serving life and income generation. In the last 7 days SA has had 14 infections per 100000 people related in the last 7 days (17 March 2021). With the discovery of the corona virus vaccine, SA has administered at least 147 753 doses of COVID-19 vaccines(COVID-19 Global Tracker, 2021) With the assumption that a person needs two doses, that's enough to have vaccinated about 0.1% of the population which is far from the aimed herd immunity figure of 60% of the population.

Recently Lukman et al(2020), used ARIMA model to forecast the trend of COVID-19 prevalence in African countries, SA included. Results noticed a form of exponential growth in the trend of this virus in Africa. Linear Regression Analysis was implemented to forecast the number of deaths in India due to COVID-19 (Ghosal et al., 2020). Reddy et al., (2021), used nonlinear growth curves to produce short-term forecasts of COVID-19 cases and deaths using publicly available data in South Africa. Results displayed that the three-parameter logistic growth model provided the utmost precise forecasts of cumulative deaths within the 10-day period, while the Gompertz model managed to well capture the fluctuations in cumulative bereavements beyond this period.

It can be argued that bothCOVID-19 new cases as well as COVID-19 mortalities are of vital importance in modelling the burden of COVID-19. The total number of cases is highly correlated to the over-all number of tests done and hence there can be a misleading indicator of the outbreak advancement. For that cause, modelling the total number of COVID-19 related deaths is of great interest. In this study, we will focus on modelling and predicting COVID-19 deaths in South Africa (SA). This will be done using the Artificial Neural Networks (ANN). Khan & Gupta, 2020; Dhamodharavadhani et al., 2020; and Arora et al., 2020), proved that ANN techniques are one of the most efficient methods of processing huge data sets like those of COVID-19 deaths.

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This study will also help monitor death trends in South Africa through the provision of reliable estimates and forecasts. Finally, the paper will help decision makers and governments make responsive decisions that help them to be well prepared and help curb coronavirus mortalities.

II. METHODOLOGY

The study applies the Artificial Neural Network (ANN) approach which is usually celebrated for its capability to learn from any data-set and consequently 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 South Africa 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	G
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	0.125377
MSE	1587.391519
MAE	23.389429

Residual Analysis for the Applied Model

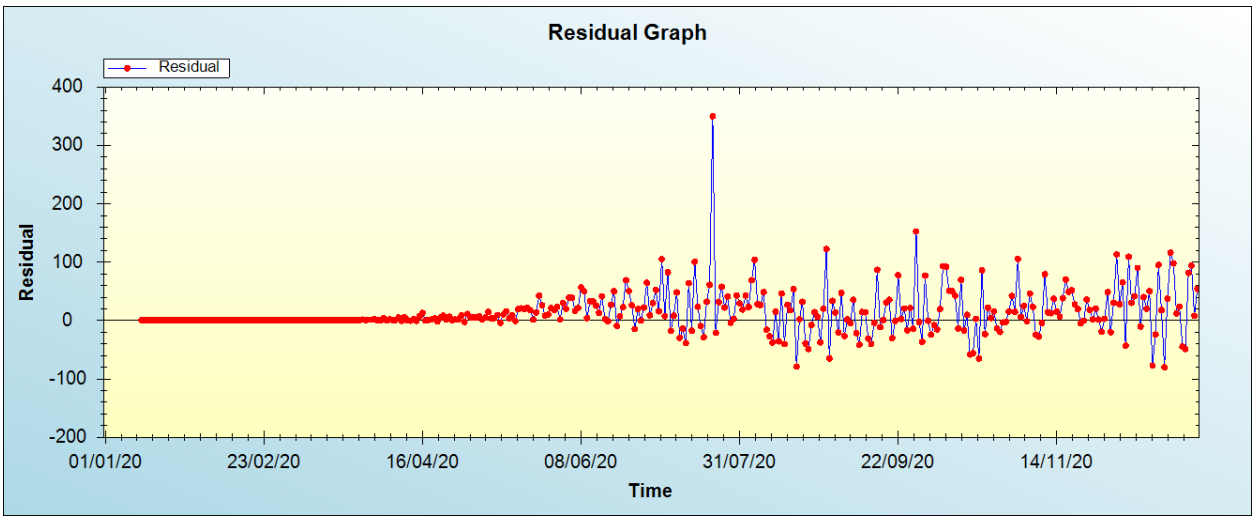

Figure 1: Residual analysis

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In-sample Forecast for G

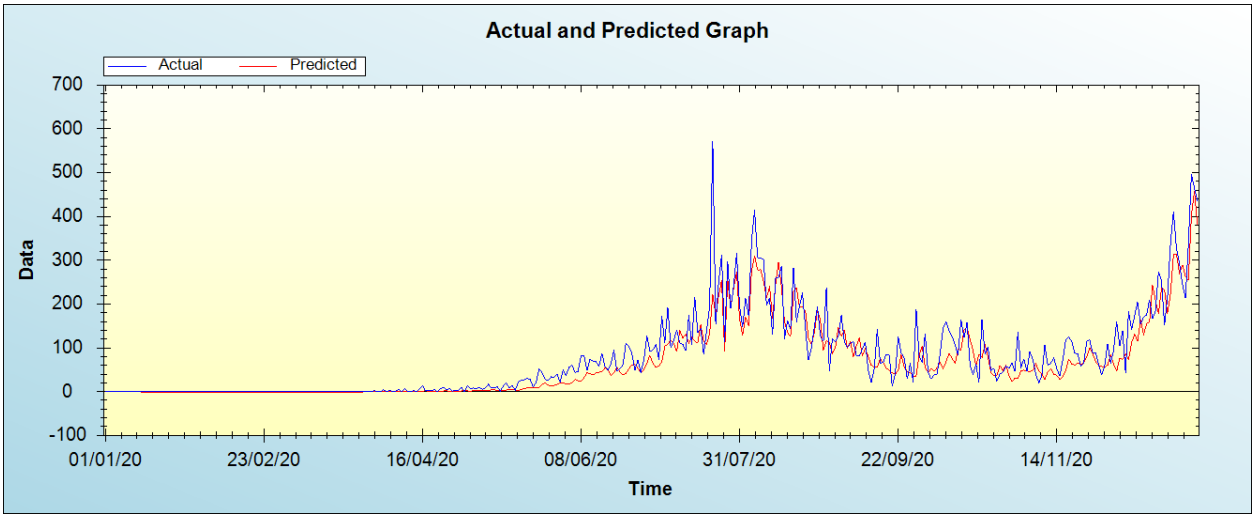

Figure 2: In-sample forecast for the G series

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

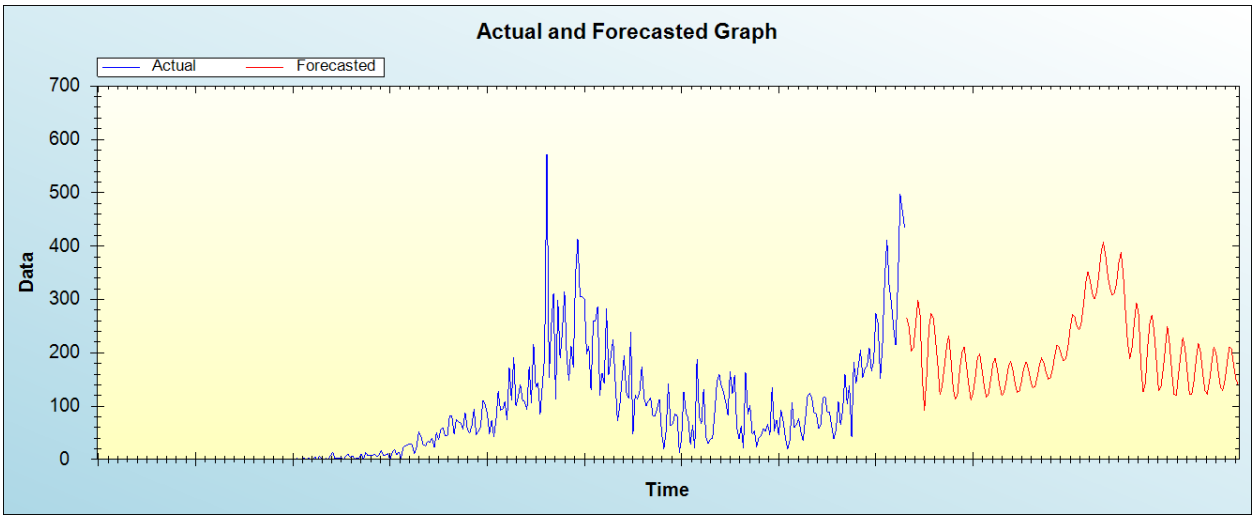

Figure 3: Out-of-sample forecast for G: actual and forecasted graph

Out-of-Sample Forecast for G: Forecasts only

Table 3: Tabulated out-of-sample forecasts

	Forecasted
01/01/21	264.8947
02/01/21	247.8983
03/01/21	203.6286
04/01/21	209.1608
05/01/21	253.2587
06/01/21	299.1642
07/01/21	269.3880
08/01/21	152.5123
09/01/21	91.5119
10/01/21	157.7760

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11/01/21	246.4959
12/01/21	274.0944
13/01/21	264.8496
14/01/21	223.7617
15/01/21	179.3929
16/01/21	121.1863
17/01/21	137.6716
18/01/21	172.6402
19/01/21	211.1969
20/01/21	232.3946
21/01/21	186.2070
22/01/21	131.6656
23/01/21	112.2636
24/01/21	123.7050
25/01/21	170.3385
26/01/21	200.8336
27/01/21	210.7501
28/01/21	176.5285
29/01/21	140.0728
30/01/21	110.6547
31/01/21	125.3298
01/02/21	153.1731
02/02/21	190.3703
03/02/21	198.0388
04/02/21	170.0992
05/02/21	137.1791
06/02/21	116.4520
07/02/21	123.2250
08/02/21	149.7745
09/02/21	179.4344
10/02/21	189.9129
11/02/21	167.7103
12/02/21	138.1606
13/02/21	120.3039
14/02/21	125.1983
15/02/21	147.1678
16/02/21	173.8267
17/02/21	184.4821
18/02/21	167.2193
19/02/21	142.4353
20/02/21	125.5008
21/02/21	128.8376
22/02/21	147.6877
23/02/21	171.9221
24/02/21	183.5372
25/02/21	170.8898
26/02/21	149.2481
27/02/21	134.4228
28/02/21	136.1489
01/03/21	153.1343

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02/03/21	176.7251
03/03/21	190.5419
04/03/21	182.0668
05/03/21	163.6921
06/03/21	150.6911
07/03/21	152.4356
08/03/21	169.5214
09/03/21	195.6166
10/03/21	214.5411
11/03/21	210.3021
12/03/21	194.4678
13/03/21	184.5422
14/03/21	189.4422
15/03/21	211.8362
16/03/21	246.5186
17/03/21	272.2102
18/03/21	267.5256
19/03/21	250.1520
20/03/21	243.4331
21/03/21	255.4285
22/03/21	288.5911
23/03/21	330.8881
24/03/21	351.3952
25/03/21	335.1662
26/03/21	310.1642
27/03/21	300.7512
28/03/21	314.1776
29/03/21	348.1311
30/03/21	388.8150
31/03/21	406.6833
01/04/21	382.9755
02/04/21	345.0497
03/04/21	320.6749
04/04/21	308.4426
05/04/21	311.7676
06/04/21	332.0237
07/04/21	369.0298
08/04/21	388.3384
09/04/21	347.2044
10/04/21	277.9918
11/04/21	218.6652
12/04/21	189.1026
13/04/21	210.3139
14/04/21	257.1503
15/04/21	294.3997
16/04/21	271.2057
17/04/21	177.1166
18/04/21	126.7612
19/04/21	141.9344
20/04/21	209.7893

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21/04/21	254.2105
22/04/21	271.1462
23/04/21	237.4146
24/04/21	186.5361
25/04/21	129.8374
26/04/21	134.1641
27/04/21	166.2701
28/04/21	208.5112
29/04/21	249.0309
30/04/21	215.7363
01/05/21	163.2050
02/05/21	121.6255
03/05/21	120.0428
04/05/21	158.9103
05/05/21	197.4526
06/05/21	228.2297
07/05/21	207.5844
08/05/21	163.5848
09/05/21	123.0043
10/05/21	121.2981
11/05/21	147.2991
12/05/21	186.8022
13/05/21	217.5576
14/05/21	200.4068
15/05/21	162.8061
16/05/21	129.2641
17/05/21	122.4234
18/05/21	145.6434
19/05/21	179.4708
20/05/21	210.4269
21/05/21	200.4601
22/05/21	166.5104
23/05/21	136.5147
24/05/21	129.0665
25/05/21	147.0049
26/05/21	179.5970
27/05/21	210.5570
28/05/21	206.8724
29/05/21	177.3137
30/05/21	149.7222
31/05/21	141.0657

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 mortality in South Africa will basically range between 100 and 300 deaths per day over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

In this study, ANN-based models were used to predict coronavirus deaths in South Africa. The results indicated the need for more research on the alignment of confirmed cases and testing efficiency. Advise is for further estimations to be based on death rates per province so as to ascertain the magnitude of the effect of the virus. South Africa is advised to have enough supplies

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stocked in disaster prone areas, for example the Eastern Cape. These include masks, testing kits and also for awareness campaigns to be intensified, this will help people learn of the need to stay physically distanced and sanitized in order to avoid the rise of a third wave due to wanning immunity. The South African government is advised to focus on ensuring testing efficiency and set up satellite Covid-19 testing sites that offer free testing was possible.

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