Forecasting Confirmed Cases of Covid-19 in Namibia Using Artificial Neural Networks

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Abstract - **In this research article, the ANN approach was applied to analyze daily COVID-19 cases in Namibia. The employed data covers the period 1 January 2020 to 31 December 2020 and the out-of-sample period ranges over the period 1 January 2021 to 31 May 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied ANN (12, 12, 1) model indicate that the model i daily COVID-19 cases is stable in forecasting daily new COVID-19 cases in Namibia. The model predictions suggest that daily COVID-19 cases are likely to be between 0-800 cases per day over the period 1 January 2021 to 31 May 2021. Therefore the government should continue enforcing adherence to WHO guidelines on prevention and control of COVID-19.**

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

Artificial neural networks (ANNs) are electronic models based on the architecture and function of the human brain (Kishan, 1997; Patterson, 1995). They are flexible computational frameworks for modelling a large range of nonlinear data or problems. ANNs can be applied a wide range of data types for prediction with a high level of accuracy (Zhao et al, 2020; Nyoni et al, 2020; Paswan et al, 2018; Gomes et al., 2011; Ozkan & Erbek, 2003; Zhang, 2003).The main features of the ANN model are determined by the characteristics of the data (Zhang, 2003). In time series modeling and forecasting the predominant ANN framework is the multilayer perceptron (MLP) or single hidden layer feed forward neural network (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 model consists of 3 layers of neurons: input, hidden and output layers connected by acyclic links. In supervised learning the ANN learns the predictor function by taking advantage of the desired outputs provided by the supervisor. The synaptic weights of the network are adjusted under the influence of the error signal (Zhang, 2003).The adjustment occurs in a step by step fashion until the desired results are obtained. In this paper we apply the ANN (12, 12, 1) approach to model and forecast daily COVID-19 cases in Namibia. The results of the study are expected to provide an insight of the future trends of daily COVID-19 cases in Namibia and help in the assessment of COVID-19 mitigatory measures in the country.

II. LITERATURE REVIEW

Table 1: Review of Literature

Author (s)	Study period	Method	Findings
Argawu (2020)	March – August, 2020	OLS Model	Number of new laboratory tests and number of new cases from Addis Ababa city significantly predicted COVID-19 new cases
Deressa & Duresa (2020)	March – August, 2020	Compartmental Model	The diseases free and endemic equilibrium points are locally and globally asymptotically stable. A combination of optimal preventive

			strategies such as public health education, personal protective measures and treatment of hospitalized cases are effective to significantly decrease the number of COVID-19 cases in Ethiopia
Egwuche et al. (2020)	February – June, 2020	SEIR model	The proposed model shows an accuracy of 72%. The COVID-19 pandemic is spreading very fast in Nigeria
Nurudeen et al. (2020)	February – May, 2020	ARIMA	The best model is the ARIMA (1, 2, 1) model
Nyoni et al (2020)	March 20, 2020 to December 10, 2020	ANN model	Zimbabwe is likely to record between 0-330 new cases per day over the period 11 December 2020 to 29 April 2021

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 Namibia 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	W
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	0.500590
MSE	682.490027
MAE	17.585180

Residual Analysis for the Applied Model
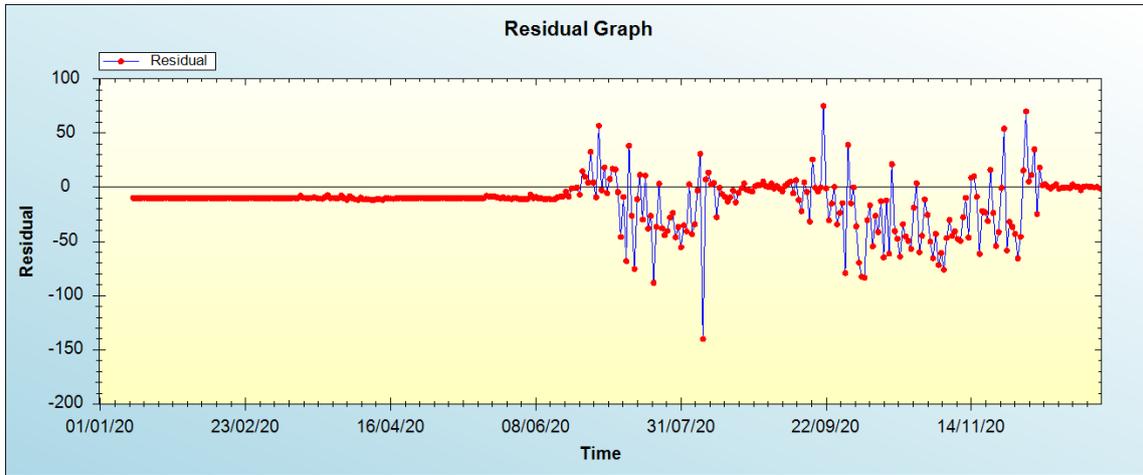

Figure 1: Residual analysis

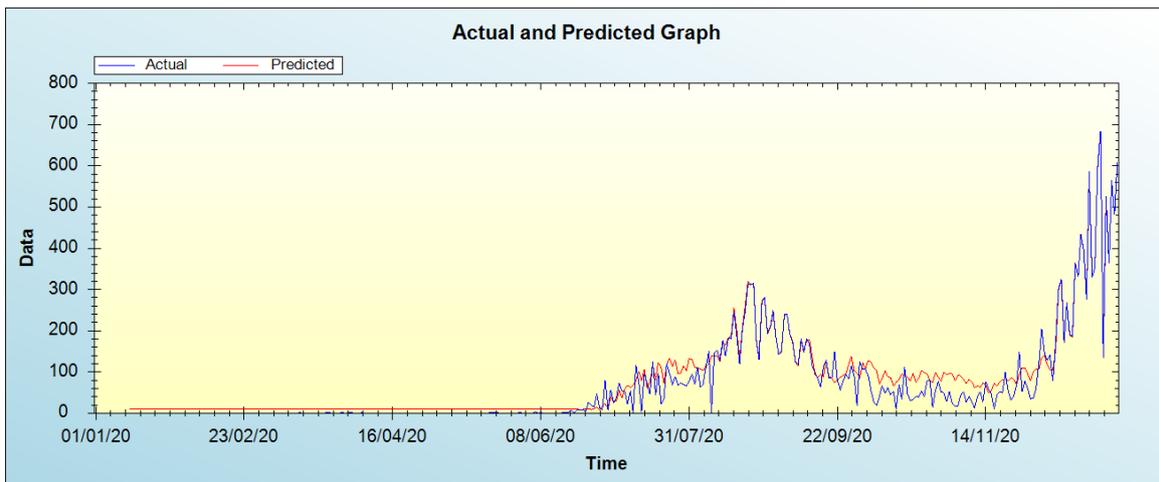*In-sample Forecast for W*

Figure 2: In-sample forecast for the W series

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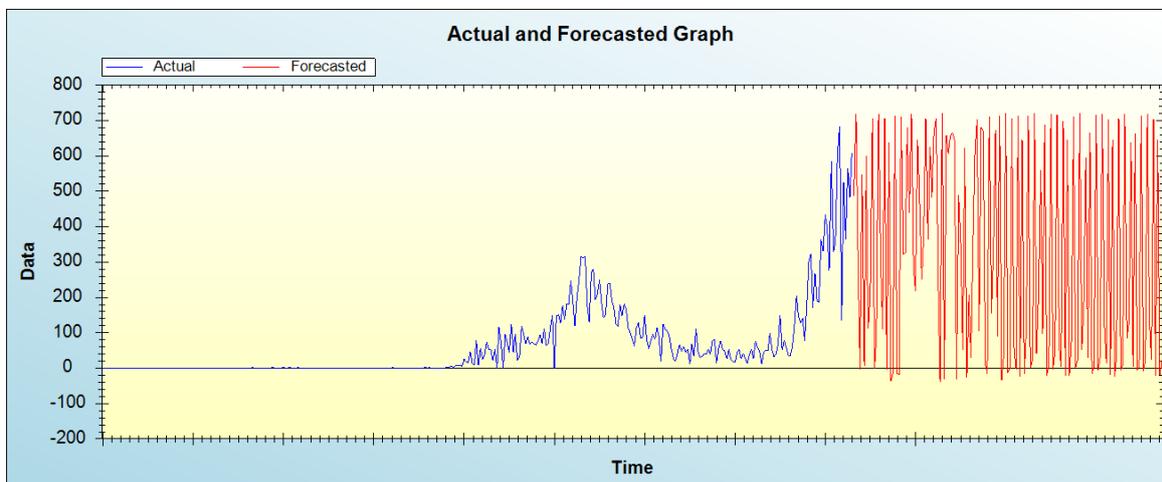

Figure 3: Out-of-sample forecast for W: actual and forecasted graph

Out-of-Sample Forecast for W: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasted daily COVID-19 cases
01/01/21	487.8988
02/01/21	719.5271
03/01/21	302.8516
04/01/21	-1.4225
05/01/21	547.9939
06/01/21	7.2223
07/01/21	598.9346
08/01/21	111.9575
09/01/21	213.1228
10/01/21	704.9461
11/01/21	0.7568
12/01/21	88.5768
13/01/21	717.8667
14/01/21	302.1672
15/01/21	109.6224
16/01/21	706.0546
17/01/21	-2.8470
18/01/21	638.4520
19/01/21	-36.7036
20/01/21	-13.3323
21/01/21	711.7746
22/01/21	-15.1110
23/01/21	-18.0123
24/01/21	710.0002
25/01/21	322.6018
26/01/21	326.7151
27/01/21	679.1679
28/01/21	440.2149

29/01/21	719.0325
30/01/21	282.7091
31/01/21	218.5945
01/02/21	645.2483
02/02/21	454.9217
03/02/21	251.3912
04/02/21	376.7339
05/02/21	706.2007
06/02/21	363.4667
07/02/21	625.1958
08/02/21	482.5977
09/02/21	668.4205
10/02/21	705.1055
11/02/21	243.8576
12/02/21	-37.5879
13/02/21	720.3508
14/02/21	-30.0478
15/02/21	659.4186
16/02/21	605.4039
17/02/21	656.9224
18/02/21	665.6565
19/02/21	645.0465
20/02/21	-30.0959
21/02/21	488.1209
22/02/21	353.3805
23/02/21	52.2411
24/02/21	621.4574
25/02/21	-25.1051
26/02/21	208.1417
27/02/21	28.9443
28/02/21	362.0175

01/03/21	616.6466
02/03/21	702.1892
03/03/21	105.4696
04/03/21	681.9227
05/03/21	670.6378
06/03/21	11.2061
07/03/21	-15.2585
08/03/21	711.5489
09/03/21	156.6941
10/03/21	336.4148
11/03/21	673.4643
12/03/21	90.4651
13/03/21	714.0270
14/03/21	-33.8804
15/03/21	36.0000
16/03/21	720.4460
17/03/21	-12.7435
18/03/21	-0.4023
19/03/21	705.9085
20/03/21	62.8896
21/03/21	-3.5114
22/03/21	712.5826
23/03/21	-22.2323
24/03/21	646.0056
25/03/21	-14.6081
26/03/21	114.1557
27/03/21	712.7118
28/03/21	1.2141
29/03/21	24.6580
30/03/21	719.6425
31/03/21	42.2647

01/04/21	202.8734
02/04/21	559.2916
03/04/21	96.0736
04/04/21	688.4214
05/04/21	-20.0345
06/04/21	5.6893
07/04/21	717.7265
08/04/21	-1.5241
09/04/21	46.1678
10/04/21	716.1967
11/04/21	66.5475
12/04/21	3.9297
13/04/21	697.3619
14/04/21	-20.1804
15/04/21	644.6718
16/04/21	-20.5583
17/04/21	78.6322
18/04/21	709.7816
19/04/21	2.0534
20/04/21	22.2861
21/04/21	719.8814
22/04/21	51.6632
23/04/21	163.5248
24/04/21	594.2518
25/04/21	29.9955
26/04/21	665.5911
27/04/21	-15.4967
28/04/21	6.2928
29/04/21	715.2297
30/04/21	-5.2741
01/05/21	34.5794

02/05/21	718.2020
03/05/21	119.9340
04/05/21	15.7411
05/05/21	701.3355
06/05/21	-17.5339
07/05/21	644.7618
08/05/21	-21.9719
09/05/21	30.4376
10/05/21	707.1639
11/05/21	-4.7840
12/05/21	11.5021
13/05/21	719.0705
14/05/21	84.9526
15/05/21	130.6123
16/05/21	638.4290
17/05/21	4.6070
18/05/21	661.7224
19/05/21	-4.8310
20/05/21	4.8325
21/05/21	712.4849
22/05/21	-7.2417
23/05/21	23.7688
24/05/21	718.2712
25/05/21	133.4113
26/05/21	24.6208
27/05/21	702.4604
28/05/21	-19.8319
29/05/21	644.9156
30/05/21	-19.7024
31/05/21	21.8581

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 cases are likely to be between 0-800 cases per day over the period 1 January 2021 to 31 May 2021.

V. CONCLUSION & RECOMMENDATIONS

Machine learning (ML) boasts of its superiority to traditional statistical methods because it does not require any assumptions such as normally distributed errors with constant variance and absence of serial correlation. ML algorithms can deal with big data sets which are complex and nonlinear in nature. The applied ANN approach in this study revealed that COVID-19 cases are likely to be between 0-800 cases per day over the period 1 January 2021 to 31 May 2021. Therefore the Namibian government should continue to enforce adherence to WHO guidelines on prevention and control of COVID-19, and relentlessly encourage its citizens to get vaccinated whilst continuously addressing issues surrounding vaccine safety through mass media communication.

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