

Prediction of Confirmed Daily Covid-19 Cases in Mozambique Using Artificial Neural Networks

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Abstract - In this research paper, the ANN approach was applied to analyze daily COVID-19 cases in Mozambique. 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 is stable in forecasting daily COVID-19 cases in Mozambique. The results of the study revealed that daily COVID-19 cases are likely to follow an upward trajectory over the out of sample period. Therefore the government is encouraged to practicing WHO guidelines and protocols for the prevention and control of COVID-19.

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

A time series is a sequence of historical measurements of an observable variable at equal time intervals (Bontempi et al, 2013). Time series forecasting is the prediction of future values of time series variable based on the historical data. Time series forecasting methods can be classified into linear and nonlinear time series methods. The traditional linear time series methods include ARIMA models. ARIMA models were proposed by Box and Jenkins in the 1970s. ARIMA model building involves a 3 stage iterative procedure: model identification, parameter estimation and diagnostic checking. The best model is selected based on Akaike information criterion (Nyoni & Nyoni, 2019 a & b). The nonlinear models are the ARCH and GARCH models which are predominantly applied in financial time series forecasting (Nyoni et al, 2020). Nowadays machine learning (ML) methods are attracting the attention of many researchers all over the world in various fields such as Medicine, engineering and agriculture. ML is a sub discipline of artificial intelligence (AI). It's a scientific field where computers learn from experience (Weng et al, 2017). Algorithms for machine learning such as tree based models, K-Nearest neighbors, support vector machine, artificial neural networks and Bayesian networks are now popular in public health surveillance (Zhao et al, 2020; Nyoni et al, 2020; Weng et al, 2017). ML techniques are superior to traditional statistical methods because they can model nonlinear complex data with high accuracy.

In this paper we apply the ANN approach to model and forecast daily COVID-19 cases in Mozambique. The model is self-adaptive and inherently nonlinear and thus can handle large and complex data sets such as the daily COVID-19 case volumes. The model is made of three layers of neurons (nodes) which are 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 findings of this research are expected to provide an insight of the future trends of daily COVID-19 cases in Mozambique and facilitate planning and allocation of resources towards prevention and control of the COVID-19 epidemic.

II. LITERATURE REVIEW

Table 1: Literature Review

Author (s)	Study period	Method	Findings
Abdulmajeed et al. (2020)	February – April, 2020	GAMS, ARIMA, GARCH and ESM models	There is a progressive rise in COVID-19 cases in Nigeria

Okuonghae & Omame (2020)	February – April, 2020	SEIR model	If people comply with control and preventive measures, the disease will eventually die out in Nigeria
Nyoni et al (2020)	13 March 2020 to 31 October 2020	ANN model	daily new COVID-19 cases in Ethiopia are likely to continue declining over the period November 2020 to April 2021
Nyoni et al (2020)	March 2, 2020 to October 31, 2020	ANN model	COVID-19 cases in Morocco will initially continue to rise from 3661 on November 1, 2020 and by December 11, 2020; COVID-19 daily confirmed cases would have reached what we can term an equilibrium case volume, which shall be maintained throughout the out-of-sample period.

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 Mozambique 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	S
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	0.752470
MSE	192.837611
MAE	10.561819

Residual Analysis for the Applied Model

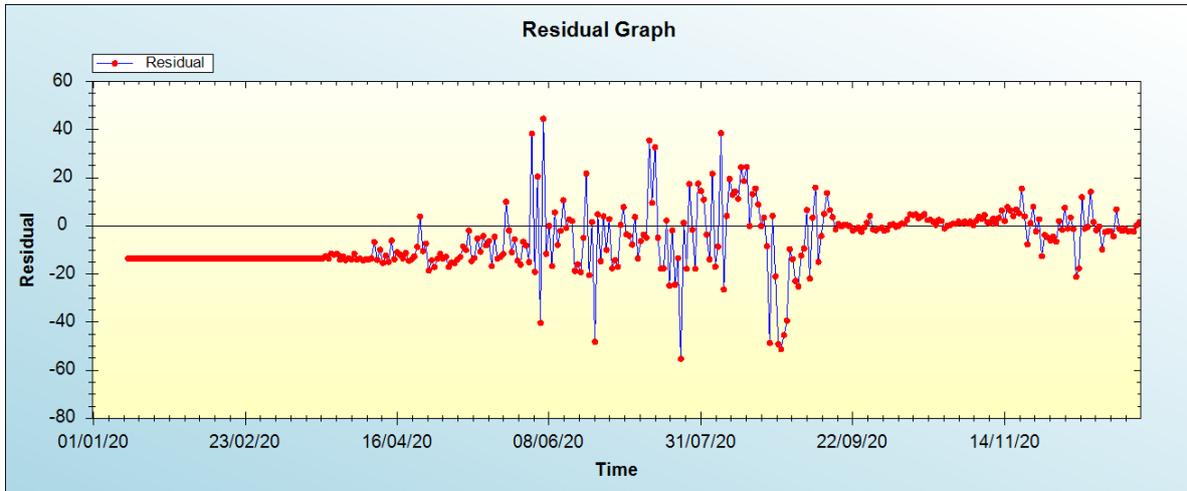


Figure 1: Residual analysis

In-sample Forecast for S

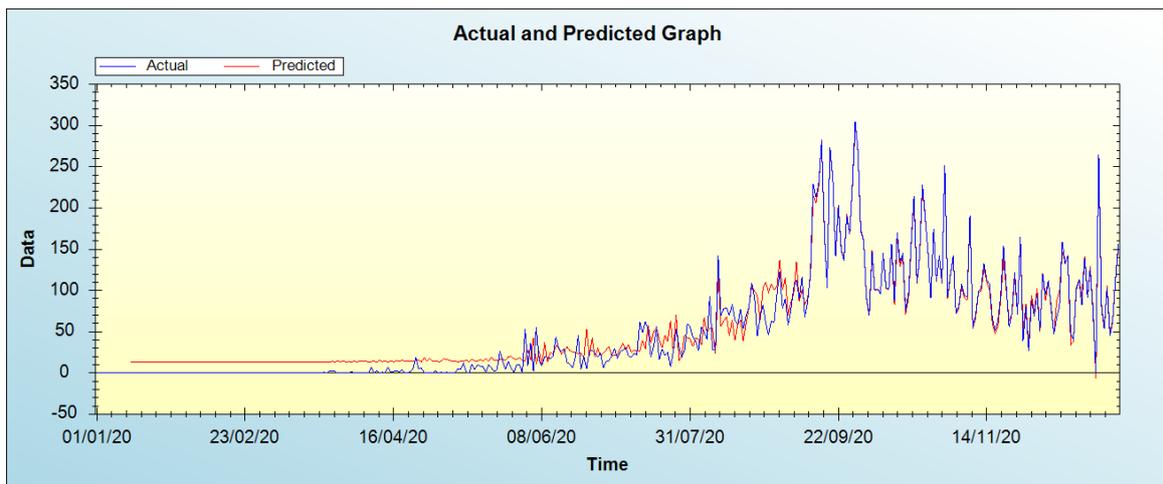


Figure 2: In-sample forecast for the S series

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

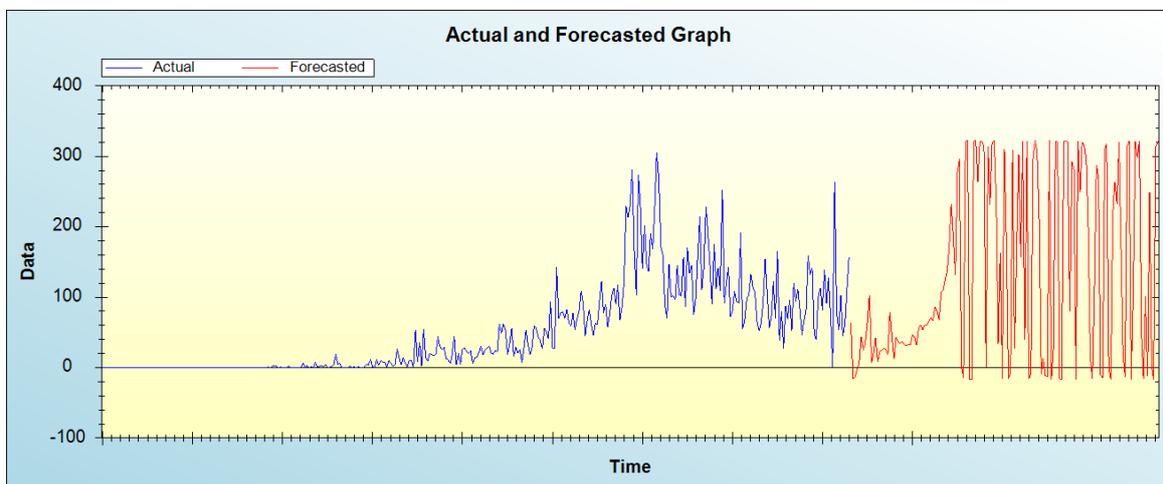


Figure 3: Out-of-sample forecast for S: actual and forecasted graph

Out-of-Sample Forecast for S: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasted daily COVID-19 cases
01/01/21	62.7586
02/01/21	-16.1453
03/01/21	-13.4257
04/01/21	-2.8069
05/01/21	5.4351
06/01/21	42.9797
07/01/21	25.1338
08/01/21	34.7127
09/01/21	62.5544
10/01/21	102.6080
11/01/21	7.1364
12/01/21	18.5230
13/01/21	42.3261
14/01/21	8.3523
15/01/21	23.1939
16/01/21	24.9381
17/01/21	27.9216
18/01/21	26.0558
19/01/21	17.9133
20/01/21	78.5965
21/01/21	43.5981
22/01/21	11.6235
23/01/21	43.4734
24/01/21	36.7043
25/01/21	34.3149
26/01/21	37.7438
27/01/21	32.3214
28/01/21	30.8816

29/01/21	33.0410
30/01/21	32.4881
31/01/21	46.9042
01/02/21	42.9848
02/02/21	31.9924
03/02/21	56.6352
04/02/21	61.2243
05/02/21	53.7213
06/02/21	60.6480
07/02/21	60.3602
08/02/21	66.2739
09/02/21	70.6154
10/02/21	66.1448
11/02/21	86.5055
12/02/21	80.3378
13/02/21	68.2236
14/02/21	106.7411
15/02/21	109.6988
16/02/21	124.3007
17/02/21	137.9520
18/02/21	174.5936
19/02/21	232.4289
20/02/21	184.5268
21/02/21	131.3624
22/02/21	277.5005
23/02/21	295.5021
24/02/21	-0.2594
25/02/21	-14.1173
26/02/21	321.3047
27/02/21	321.9404
28/02/21	-16.3187

01/03/21	-16.9419
02/03/21	321.4249
03/03/21	321.9422
04/03/21	263.3402
05/03/21	321.4186
06/03/21	320.8837
07/03/21	314.6944
08/03/21	0.9876
09/03/21	313.8054
10/03/21	231.6492
11/03/21	318.7872
12/03/21	321.8174
13/03/21	235.3995
14/03/21	33.3236
15/03/21	162.8739
16/03/21	-15.7505
17/03/21	309.8216
18/03/21	180.8579
19/03/21	-15.2370
20/03/21	-7.5415
21/03/21	308.2960
22/03/21	27.0122
23/03/21	172.4609
24/03/21	302.9072
25/03/21	156.9292
26/03/21	320.6046
27/03/21	40.3970
28/03/21	320.8519
29/03/21	-15.6052
30/03/21	-8.7400
31/03/21	296.6401

01/04/21	321.9431
02/04/21	307.4037
03/04/21	212.3962
04/04/21	-8.9437
05/04/21	12.6932
06/04/21	-11.4482
07/04/21	-12.3535
08/04/21	321.7533
09/04/21	-16.9432
10/04/21	26.2313
11/04/21	321.6290
12/04/21	319.0558
13/04/21	-16.1358
14/04/21	-16.6000
15/04/21	320.4941
16/04/21	321.9441
17/04/21	320.0562
18/04/21	80.7005
19/04/21	292.9131
20/04/21	280.7371
21/04/21	-16.9438
22/04/21	321.7810
23/04/21	248.6529
24/04/21	320.3407
25/04/21	315.2107
26/04/21	295.8672
27/04/21	194.6360
28/04/21	16.1136
29/04/21	-15.2108
30/04/21	112.4621
01/05/21	287.0684

02/05/21	270.6830
03/05/21	-10.1348
04/05/21	-14.3788
05/05/21	309.0611
06/05/21	318.2038
07/05/21	0.1333
08/05/21	-16.9422
09/05/21	218.4829
10/05/21	263.5209
11/05/21	232.8672
12/05/21	319.6659
13/05/21	176.3104
14/05/21	19.6353
15/05/21	-13.1000
16/05/21	314.2405
17/05/21	321.4706
18/05/21	-16.6624
19/05/21	119.0236
20/05/21	321.3538
21/05/21	297.7561
22/05/21	321.6457
23/05/21	44.4710
24/05/21	-15.9432
25/05/21	100.4586
26/05/21	-11.9894
27/05/21	249.0073
28/05/21	1.6556
29/05/21	-16.7456
30/05/21	313.5102
31/05/21	321.3620

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 predicted that daily COVID-19 cases are likely to follow an upward trajectory over the out of sample period.

V. CONCLUSION & RECOMMENDATIONS

Artificial neural network technique is becoming the predominant machine learning algorithm in time series forecasting in public health (Nyoni et al, 2020). The multilayer perceptron is the ANN framework which has gained more popularity when compared to other ANN frameworks. The model is self-adaptive and can model nonlinear data with high accuracy. The results of this study indicated that daily COVID-19 cases are likely to follow an upward trajectory over the out of sample period. Therefore the government is encouraged to continuously enforce WHO guidelines on prevention and control of COVID-19.

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