

Forecasting Confirmed Covid-19 Cases in Malawi Using Artificial Neural Networks

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Abstract - In this research article, the ANN approach was applied to analyze daily new corona virus infections in Malawi. 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 Malawi. The results of the study indicate that daily COVID-19 cases are likely to be in the range 0-270 cases over the out of sample period. Therefore the health authorities are encouraged to continue enforcing the adherence to WHO guidelines and protocols in order to prevent and control COVID-19 including vaccination of the majority of citizens to achieve herd immunity.

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

Public health surveillance involves systematic, continuous, data collection, analysis, interpretation and dissemination of appropriate health data to decision makers for action. The purpose of surveillance systems is to detect abnormal epidemiologic trends and facilitation of planning and resource allocation. The application of machine learning (ML) in public health surveillance has attracted attention of many public health specialists because of its advantages associated the artificial intelligence (AI) technology (Nyoni et al, 2020). AI is the field in which computers understand the nature the data by utilizing computer programs. These computer programs can learn a predictor function which can be using for prediction or generalization. ML can be classified into supervised, unsupervised, semi supervised and re-enforcement learning. Supervised learning occurs when the algorithm learns the relationship between the inputs and out puts when the desired outputs are provided by the supervisor whereas unsupervised learning occurs when the algorithm discovers hidden patterns in the input data (Weng et al, 2017). Semi-supervised learning is a mixture of supervised and unsupervised learning approaches. In re-enforcement learning the algorithm maximizes on rewards (Nyoni et al, 2020; Zhao et al, 2020; Zeng et al, 2021; Yan et al, 2018; Kaushik & Sahi ,2018; Fojnica et al, 2016, Zhang, 2003).

The objective of this paper is to model and forecast daily COVID-19 cases in Malawi using the artificial neural network approach. The ANN architecture is made up of three layers: the input layer which collects data, an output layer which produces computed information, and one or more hidden layers suitable to connect the input and output layer (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). A neuron is a basic processing unit of a neural network and performs two functions: the collecting of the inputs and producing of the output. Each input is multiplied by connection weights, and its products and biases are added and then passed through an activation function to produce an output. A multilayer feed forward network has neurons structured into layers and can pass in one direction without feedback connection.

The Back propagation algorithm is the most popular method used for training feed forward ANNs which is dependent on the gradient descent optimization technique. Back propagation is a technique based on supervised learning (Rogers, 1996) that is used for training neural networks, and it is processed to learn samples iteratively. The purpose of training is to minimize the mean square error. Specifically for this study we applied the ANN (12, 12, 1) model to predict daily COVID-19 cases in Malawi. The findings of this work is envisioned to reveal the future trends of daily COVID-19 cases and facilitate planning and allocation of resources for the COVID-19 response.

II. LITERATURE REVIEW

Table 1: Literature Review

Author (s)	Study Period	Method	Findings
Aslam et al. (2020)	February – April	ARIMA model	There was high exponential growth in the number of confirmed cases in Pakistan
Iftikhar & Rind (2020)	February – August, 2020	AR, MA, ARMA, NPAR, and SES models	Confirmed cases are still increasing in Pakistan
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
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.
Yousaf et al. (2020)	February – April, 2020	ARIMA model	There was high exponential growth in the number of confirmed cases, deaths and recoveries in Pakistan

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 Malawi 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	A
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	0.666038
MSE	88.921378
MAE	6.608279

Residual Analysis for the Applied Model

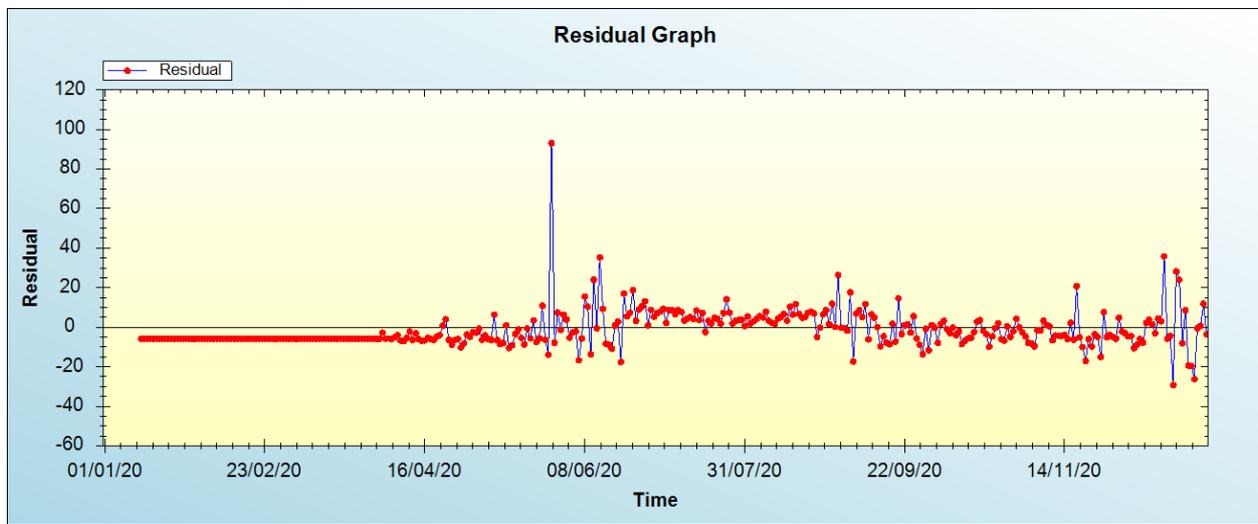


Figure 1: Residual analysis

In-sample Forecast for A

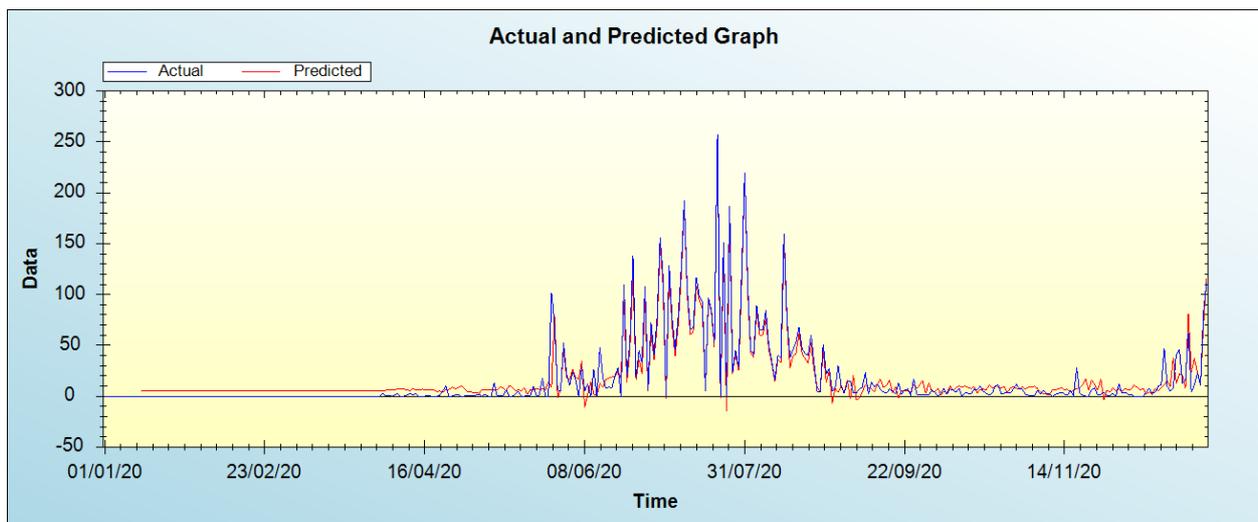


Figure 2: In-sample forecast for the A series

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

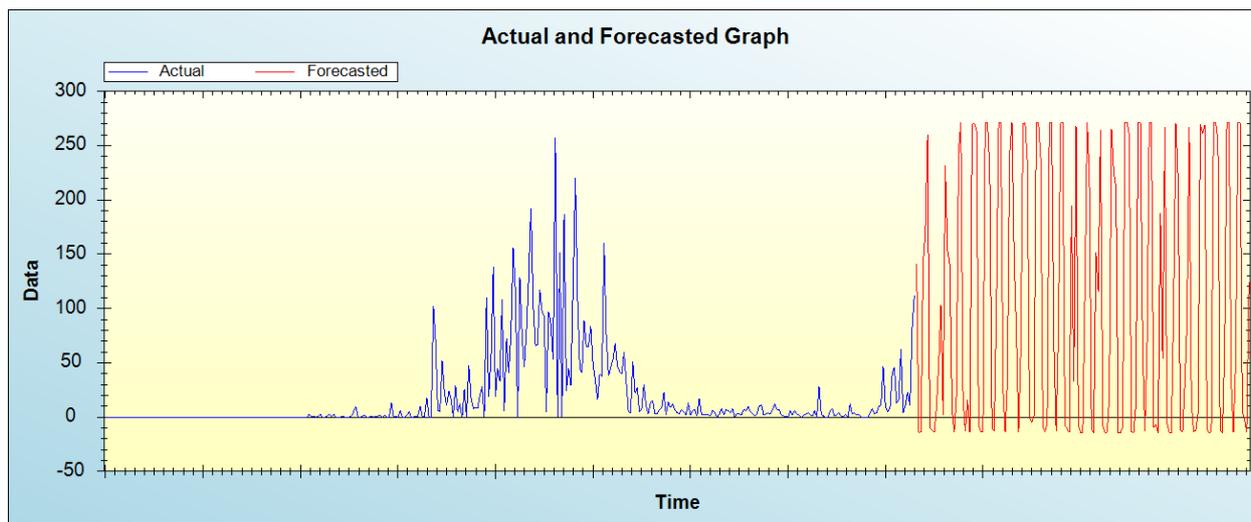


Figure 3: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasted Daily COVID-19 cases
01/01/21	141.2667
02/01/21	-14.0533
03/01/21	-13.5969
04/01/21	142.4469
05/01/21	169.4176
06/01/21	259.5844
07/01/21	-9.4215
08/01/21	-12.1163
09/01/21	-13.6712
10/01/21	9.4382
11/01/21	48.2933
12/01/21	102.9849
13/01/21	1.9601
14/01/21	231.1924
15/01/21	153.6260
16/01/21	139.6838
17/01/21	6.7757
18/01/21	-14.1852

19/01/21	21.1954
20/01/21	246.7659
21/01/21	271.0268
22/01/21	16.6931
23/01/21	-12.6709
24/01/21	15.5858
25/01/21	-13.8559
26/01/21	269.3494
27/01/21	270.5359
28/01/21	264.7789
29/01/21	-7.2178
30/01/21	-13.3076
31/01/21	-13.1501
01/02/21	271.2620
02/02/21	271.2694
03/02/21	227.4882
04/02/21	-11.0257
05/02/21	-12.2697
06/02/21	100.0544
07/02/21	271.2200
08/02/21	271.2611
09/02/21	26.5167
10/02/21	-14.1668
11/02/21	31.8186
12/02/21	241.2890
13/02/21	271.2122
14/02/21	144.2856
15/02/21	79.2854
16/02/21	-14.0376
17/02/21	59.0410
18/02/21	270.1487

19/02/21	271.2727
20/02/21	235.2827
21/02/21	-0.5980
22/02/21	-4.5166
23/02/21	1.3101
24/02/21	271.0287
25/02/21	271.2737
26/02/21	239.8954
27/02/21	-8.5134
28/02/21	-13.2199
01/03/21	-6.2979
02/03/21	271.2599
03/03/21	271.2776
04/03/21	64.5031
05/03/21	-13.2454
06/03/21	76.7492
07/03/21	270.8541
08/03/21	271.0528
09/03/21	-7.6231
10/03/21	-10.7241
11/03/21	-14.2712
12/03/21	194.7443
13/03/21	33.3010
14/03/21	267.5759
15/03/21	-7.9128
16/03/21	-14.0790
17/03/21	-14.1858
18/03/21	117.9746
19/03/21	271.1300
20/03/21	225.0350
21/03/21	-11.1610

22/03/21	-14.2663
23/03/21	151.8165
24/03/21	116.0642
25/03/21	264.5335
26/03/21	-7.5228
27/03/21	-14.2449
28/03/21	-13.6922
29/03/21	17.8693
30/03/21	265.3183
31/03/21	225.6391
01/04/21	212.1849
02/04/21	-14.2683
03/04/21	-14.1873
04/04/21	-9.3659
05/04/21	271.0266
06/04/21	271.2591
07/04/21	260.1711
08/04/21	-13.2784
09/04/21	-14.2358
10/04/21	11.7983
11/04/21	271.2559
12/04/21	271.2775
13/04/21	61.0756
14/04/21	-13.0869
15/04/21	63.6324
16/04/21	271.0724
17/04/21	271.1673
18/04/21	-9.3144
19/04/21	-6.7993
20/04/21	-14.2636
21/04/21	187.5892

22/04/21	54.0152
23/04/21	266.6029
24/04/21	-6.0075
25/04/21	-14.1848
26/04/21	-14.2047
27/04/21	100.3069
28/04/21	270.5883
29/04/21	217.9538
30/04/21	-11.7412
01/05/21	-14.2712
02/05/21	30.9617
03/05/21	88.5619
04/05/21	267.2057
05/05/21	13.3377
06/05/21	-13.2978
07/05/21	-12.4453
08/05/21	3.2221
09/05/21	269.0934
10/05/21	261.2752
11/05/21	269.0077
12/05/21	-11.6518
13/05/21	-14.2770
14/05/21	-13.3734
15/05/21	271.2509
16/05/21	271.2626
17/05/21	255.5247
18/05/21	-12.1142
19/05/21	-14.0288
20/05/21	63.1819
21/05/21	271.2493
22/05/21	271.2702

23/05/21	31.3451
24/05/21	-13.8807
25/05/21	48.3358
26/05/21	270.9022
27/05/21	271.2230
28/05/21	4.4009
29/05/21	-1.7877
30/05/21	-14.2188
31/05/21	124.3351

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 in the range 0-270 cases over the out of sample period.

V. CONCLUSION & RECOMMENDATIONS

Artificial intelligence is an important tool in public health surveillance. Many researchers around the world are advocating for the increased use of AIs in public health in order to improve the quality of care of patients. AI helps in the screening, prognosis, diagnosis and time series modeling and forecasting. The ANN approach applied in this study to analyze daily new COVID-19 cases in Malawi revealed that daily COVID-19 cases are likely to be in the range 0-270 cases over the out of sample period. Therefore the government must continuously enforce WHO guidelines on prevention and control of COVID-19 including vaccinations.

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