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Forecasting Covid-19 New Cases in Bhutan

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***Abstract* - COVID-19 continues to significantly threaten human lives and economies around the globe. In this study, the ANN approach was applied to analyze COVID-19 cases in Bhutan. This study is based on monthly new cases of COVID-19 in Bhutan for the period 1 January 2020 – 25 March 2021. The out-of-sample forecast covers the period 26 March 2021 – 31 July 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model reveal that the model is stable in forecasting COVID-19 cases in Bhutan. It is projected that daily COVID-19 cases in Bhutan are likely to remain significantly very low over the out-of-sample period. The government should ensure the continued compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so on, as well as vaccinations, in consistency with WHO guidelines on COVID-19 mitigation strategies.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

COVID-19 was first reported in Wuhan, Hubei province, China, in late December 2019 (Yang *et al*., 2020). The infection generally targets the human respiratory system and is primarily transmitted by respiratory droplets and close contact with an infected person (Rothan & Byrareddy, 2020). Common signs of COVID-19 include fever, shortness of breath and dry coughs. Uncommon symptoms of COVID-19 include muscle pain, mild diarrhoea, abdominal pain, sputum production, loss of smell and sore throat (Wang *et al*., 2020; Hu *et al*., 2020; Tao *et al*., 2020). Most COVID-19 patients experience mild to moderate respiratory illness, and they recover without requiring special treatment (Guan *et al*., 2020). In this paper, we propose the use a basic Artificial Neural Network (ANN) model, a deep learning approach; that can adequately and accurate forecast COVID-19 cases in Bhutan.

II. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting new COVID-19 cases Bhutan.

Data Issues

This study is based on daily new cases of COVID-19 in Bhutan for the period 1 January 2020 – 25 March 2021.The out-of-sample forecast covers the period 26 March 2021 – 30 September 2021.All the data employed in this research paper was gathered from the Johns Hopkins University (USA).

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	B
Observations	438 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12

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Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.091817
MSE	8.453821
MAE	1.947612

Residual Analysis for the Applied Model

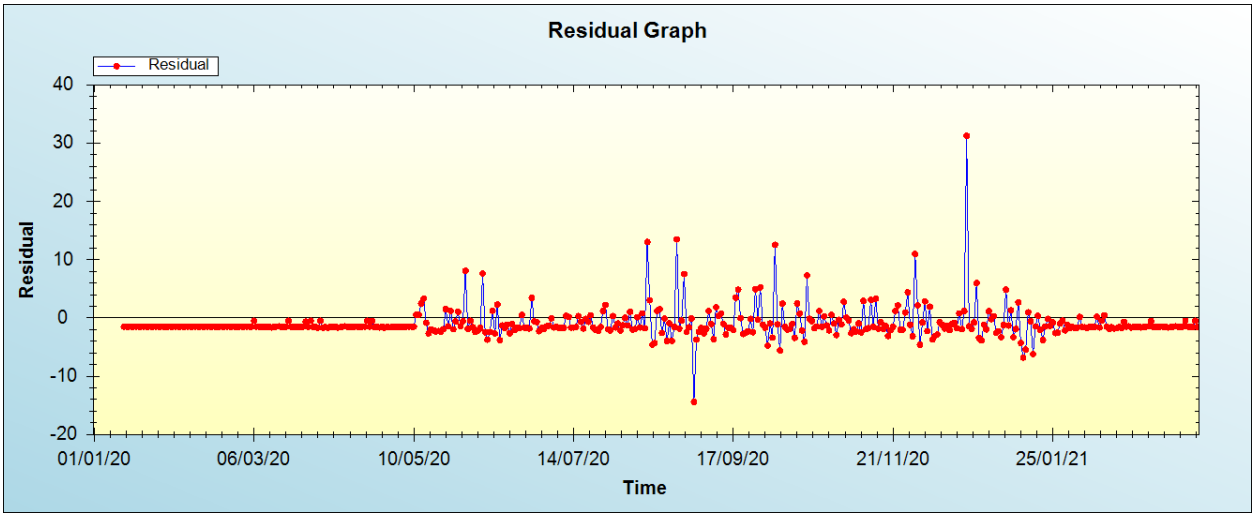

Figure 1: Residual analysis

In-sample Forecast for B

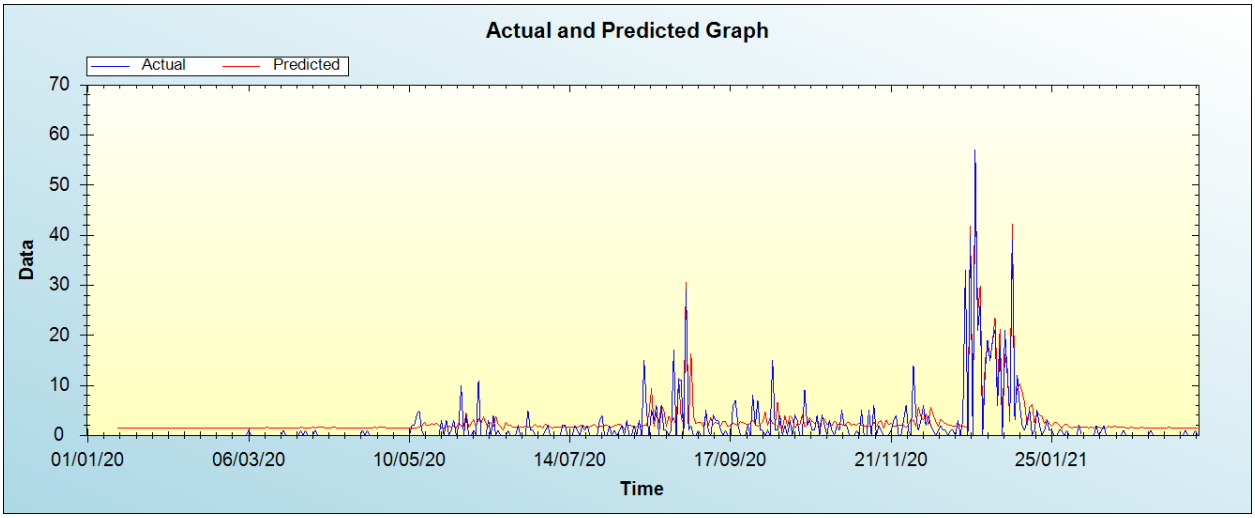

Figure 2: In-sample forecast for the B series

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

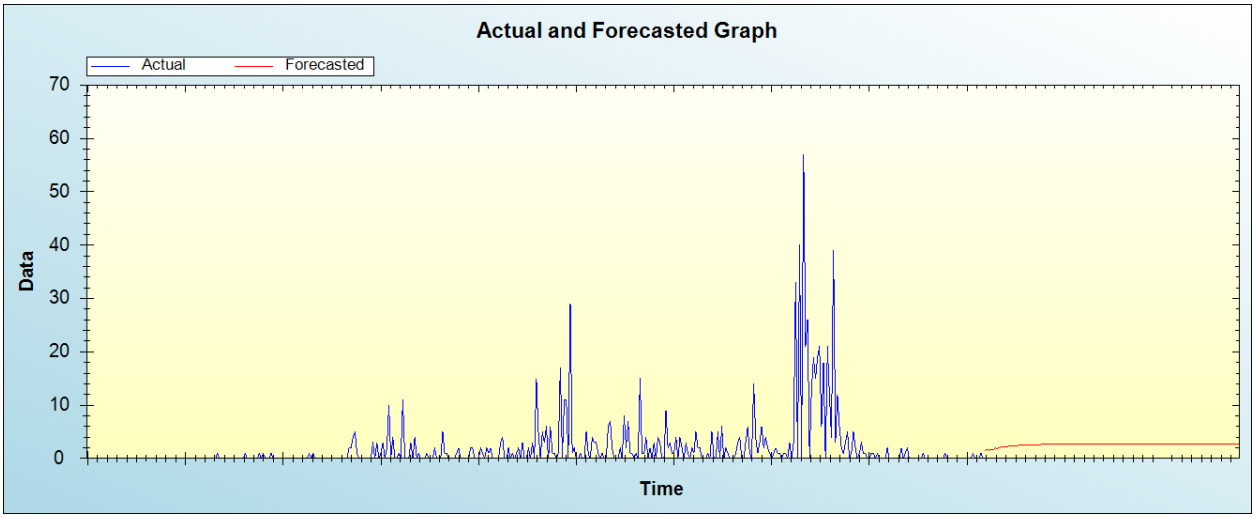

Figure 3: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
26/03/21	1.4877
27/03/21	1.6909
28/03/21	1.5520
29/03/21	1.6926
30/03/21	1.5786
31/03/21	1.9283
01/04/21	1.8912
02/04/21	1.9678
03/04/21	2.1733
04/04/21	2.1472
05/04/21	2.1942
06/04/21	2.1570
07/04/21	2.2974
08/04/21	2.3502
09/04/21	2.3467
10/04/21	2.4137
11/04/21	2.4196
12/04/21	2.4542
13/04/21	2.4564
14/04/21	2.4863
15/04/21	2.5311
16/04/21	2.5311
17/04/21	2.5503
18/04/21	2.5593
19/04/21	2.5764
20/04/21	2.5881
21/04/21	2.5945
22/04/21	2.6136
23/04/21	2.6190
24/04/21	2.6261
25/04/21	2.6322
26/04/21	2.6392
27/04/21	2.6479
28/04/21	2.6509
29/04/21	2.6577
30/04/21	2.6622
01/05/21	2.6657

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02/05/21	2.6695
03/05/21	2.6725
04/05/21	2.6769
05/05/21	2.6792
06/05/21	2.6817
07/05/21	2.6843
08/05/21	2.6862
09/05/21	2.6884
10/05/21	2.6899
11/05/21	2.6918
12/05/21	2.6934
13/05/21	2.6945
14/05/21	2.6958
15/05/21	2.6969
16/05/21	2.6980
17/05/21	2.6989
18/05/21	2.6997
19/05/21	2.7006
20/05/21	2.7012
21/05/21	2.7018
22/05/21	2.7024
23/05/21	2.7030
24/05/21	2.7035
25/05/21	2.7039
26/05/21	2.7043
27/05/21	2.7046
28/05/21	2.7050
29/05/21	2.7053
30/05/21	2.7055
31/05/21	2.7058
01/06/21	2.7060
02/06/21	2.7062
03/06/21	2.7064
04/06/21	2.7066
05/06/21	2.7068
06/06/21	2.7069
07/06/21	2.7070
08/06/21	2.7071
09/06/21	2.7073
10/06/21	2.7074
11/06/21	2.7074
12/06/21	2.7075
13/06/21	2.7076
14/06/21	2.7077
15/06/21	2.7077
16/06/21	2.7078
17/06/21	2.7078
18/06/21	2.7079
19/06/21	2.7079
20/06/21	2.7080
21/06/21	2.7080
22/06/21	2.7080
23/06/21	2.7081
24/06/21	2.7081
25/06/21	2.7081
26/06/21	2.7081
27/06/21	2.7082
28/06/21	2.7082
29/06/21	2.7082
30/06/21	2.7082
01/07/21	2.7082
02/07/21	2.7082
03/07/21	2.7082
04/07/21	2.7082

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05/07/21	2.7083
06/07/21	2.7083
07/07/21	2.7083
08/07/21	2.7083
09/07/21	2.7083
10/07/21	2.7083
11/07/21	2.7083
12/07/21	2.7083
13/07/21	2.7083
14/07/21	2.7083
15/07/21	2.7083
16/07/21	2.7083
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23/07/21	2.7083
24/07/21	2.7083
25/07/21	2.7083
26/07/21	2.7083
27/07/21	2.7083
28/07/21	2.7083
29/07/21	2.7083
30/07/21	2.7083
31/07/21	2.7083

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 in Bhutan are likely to remain significantly very low over the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Using daily observations of COVID-19 cases in Bhutan, this study employed the ANN (12, 12, 1) model to come up with forecasts. It is projected that daily COVID-19 cases in Bhutan are likely to remain significantly very low over the out-of-sample period. The government should ensure the continued compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so on, as well as vaccinations, in consistency with WHO guidelines on COVID-19 mitigation strategies.

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