PREDICTION OF COVID-19 CASES IN COSTA RICA USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

COVID-19 is a highly contagious disease which has almost frozen the world along with its economy. Its astonishing ability of human-to-human and surface-to-human transmission has turned the world into recurrent catastrophic phases. In this research article, the ANN approach was applied to analyze COVID-19 cases in Costa Rica. The employed data covers the period March 6, 2020 to October 31, 2020 while the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of our simple model indicate that the model is stable and indeed acceptable. The results of the study basically imply that daily COVID-19 cases in Costa Rica will reach an equilibrium level of approximately 1901 cases per day around January 12, 2021 and this is likely to persist throughout the rest of the out-of-sample period. The government of Costa Rica should ensure the continued compliance to control and preventive COVID-19 measures in line with WHO standards.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

The first infected case of COVID-19 was discovered in Hubei, a province in the city of Wuhan in China, on December 31 2019 (Guan *et al*., 2020; Sohrabi *et al*., 2020) and its spread has become a global threat and the World Health Organization (WHO) declared COVID-19 a global pandemic on March 11, 2020 (WHO, 2020). The new and fast dynamics of the pandemic are challenging the health systems of different countries, Costa Rica. In the absence of vaccines or effective treatments, mitigation policies, such as social isolation and lock-down of cities, have been adopted (Reis *et al*., 2020; Shastri *et al*., 2020). Forecasting daily COVID-19 cases is crucial for policy makers and public health authorities to have informed decisions on appropriate interventions and resource allocations. Since the reporting of the first case of COVID-19 in Costa Rica on March 6, 2020, it has been a curiosity for how and how long the number of cases will increase. The study aims to forecast the number of confirmed COVID-19 cases in Costa Rica. Even-though the COVID-19 pandemic has been studied in Costa Rica, for example, Beck (2020) and Chaves *et al*. (2020), no study has used a relatively wider data set to come up with future forecasts of the trajectory of the pandemic in the country. Using Artificial Neural Networks, it is this information hiatus that we seek to fill in the case of Costa Rica

METHODOLOGY

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections. This research particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. This paper is based on daily new Covid-19 (referred to as CR series in this study) for all age groups in Costa Rica. The data covers the period 6 March 2020 to 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this paper was gathered from the COVID-19 data repository prepared by the CSSE at JH University.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
458.21	141.00	0.00000	1947.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
543.52	1.1862	0.90598	-0.47987
5% Perc.	95% Perc.	IQ range	Missing obs.
1.0000	1481.7	870.00	0

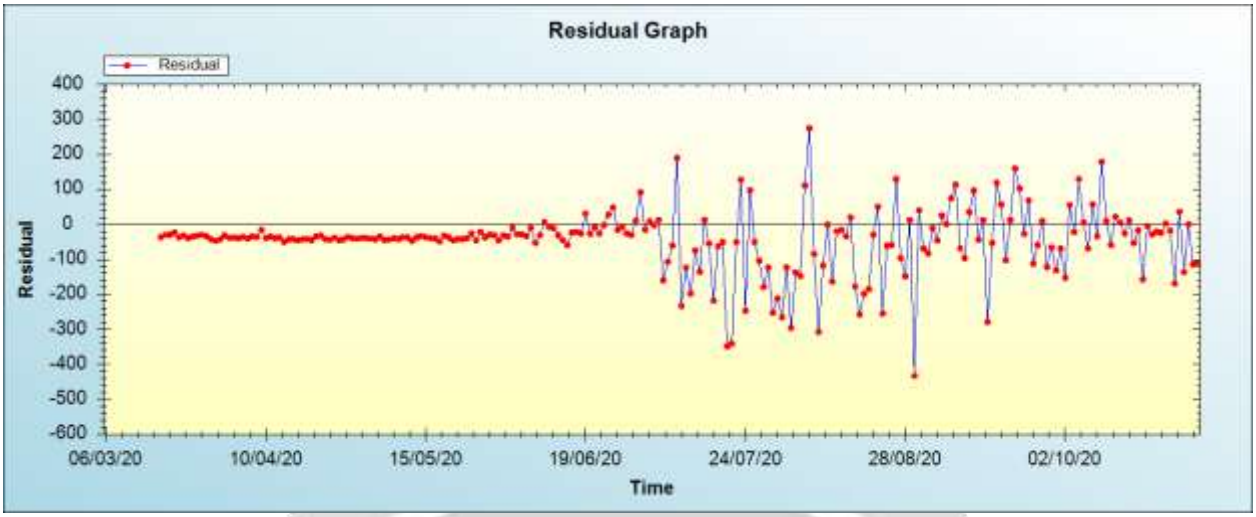
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN COSTA RICA

Table 2: ANN model summary

Variable	CR
Observations	228 (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	0.092688
MSE	10051.507118
MAE	69.353387

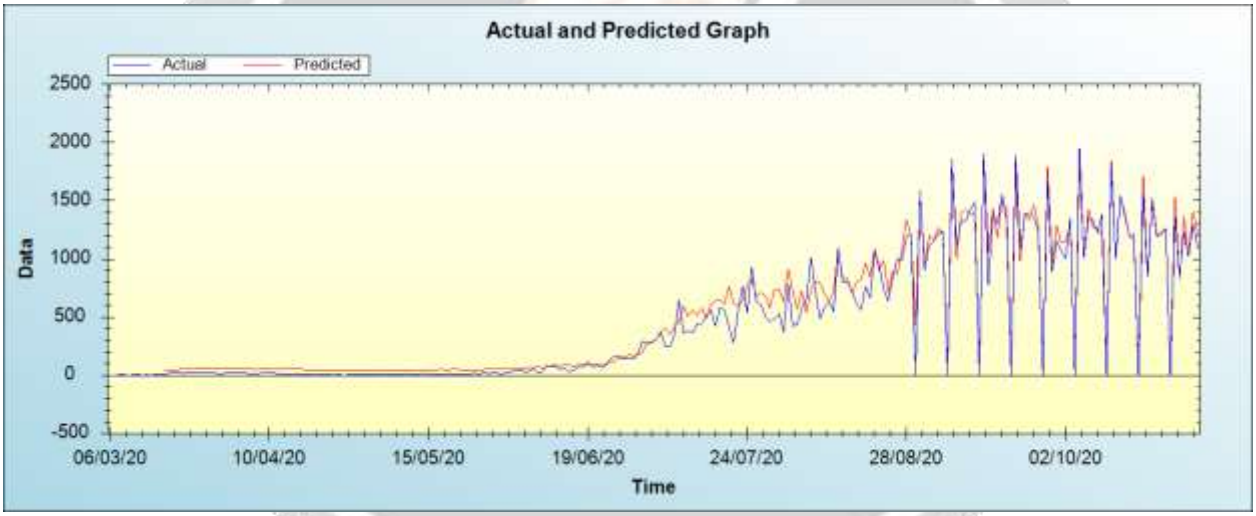
Residual Analysis for the ANN model

Figure 1: Residual analysis



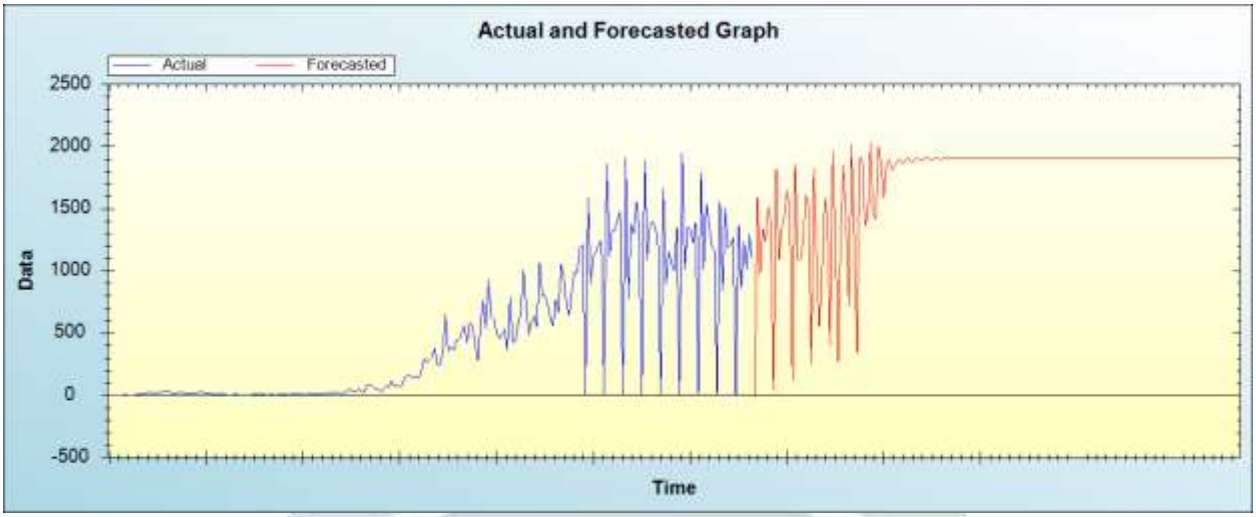
In-sample Forecast for CR

Figure 2: In-sample forecast for the CR series



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

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



Out-of-Sample Forecast for CR: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	-16.2747
02/11/20	1588.1650
03/11/20	976.7648
04/11/20	1342.2216
05/11/20	1233.0431
06/11/20	1523.6427
07/11/20	1392.4026
08/11/20	35.8476
09/11/20	1817.6651
10/11/20	1089.8873
11/11/20	1335.1707
12/11/20	1431.5095
13/11/20	1648.6469
14/11/20	1509.0137
15/11/20	117.5675

16/11/20	1861.9738
17/11/20	1085.6920
18/11/20	1096.9683
19/11/20	1246.3084
20/11/20	1611.1292
21/11/20	1514.4519
22/11/20	251.4713
23/11/20	1828.2821
24/11/20	1128.4728
25/11/20	546.1277
26/11/20	998.2820
27/11/20	1586.4005
28/11/20	1435.2754
29/11/20	403.2816
30/11/20	1962.1338
01/12/20	1226.0038
02/12/20	267.2721
03/12/20	1361.4526
04/12/20	1844.1034
05/12/20	1382.9284
06/12/20	718.1432
07/12/20	2020.7168
08/12/20	1241.1555
09/12/20	335.5316
10/12/20	1902.6307
11/12/20	1910.4690

12/12/20	1369.8055
13/12/20	1432.8065
14/12/20	2031.2059
15/12/20	1457.4855
16/12/20	1419.2314
17/12/20	2000.2849
18/12/20	1865.5291
19/12/20	1587.2979
20/12/20	1869.7107
21/12/20	1893.7912
22/12/20	1809.8491
23/12/20	1839.7868
24/12/20	1887.3279
25/12/20	1897.3328
26/12/20	1858.7648
27/12/20	1884.9754
28/12/20	1915.1203
29/12/20	1884.5265
30/12/20	1881.8531
31/12/20	1910.6215
01/01/21	1898.6677
02/01/21	1896.6084
03/01/21	1902.6605
04/01/21	1902.6091
05/01/21	1901.2896
06/01/21	1899.8913

07/01/21	1902.0160
08/01/21	1902.9363
09/01/21	1900.1348
10/01/21	1901.6794
11/01/21	1902.7894
12/01/21	1900.9745
13/01/21	1901.5323
14/01/21	1901.8473
15/01/21	1901.4742
16/01/21	1901.5511
17/01/21	1901.5118
18/01/21	1901.6343
19/01/21	1901.6232
20/01/21	1901.4232
21/01/21	1901.6227
22/01/21	1901.5908
23/01/21	1901.4636
24/01/21	1901.5800
25/01/21	1901.5614
26/01/21	1901.5276
27/01/21	1901.5586
28/01/21	1901.5431
29/01/21	1901.5516
30/01/21	1901.5484
31/01/21	1901.5369
01/02/21	1901.5566

02/02/21	1901.5461
03/02/21	1901.5417
04/02/21	1901.5534
05/02/21	1901.5461
06/02/21	1901.5458
07/02/21	1901.5493
08/02/21	1901.5463
09/02/21	1901.5480
10/02/21	1901.5475
11/02/21	1901.5468
12/02/21	1901.5485
13/02/21	1901.5470
14/02/21	1901.5472
15/02/21	1901.5481
16/02/21	1901.5471
17/02/21	1901.5475
18/02/21	1901.5477
19/02/21	1901.5473
20/02/21	1901.5476
21/02/21	1901.5475
22/02/21	1901.5474
23/02/21	1901.5476
24/02/21	1901.5474
25/02/21	1901.5475
26/02/21	1901.5475
27/02/21	1901.5474

28/02/21	1901.5475
01/03/21	1901.5475
02/03/21	1901.5475
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25/04/21	1901.5475
26/04/21	1901.5475
27/04/21	1901.5475
28/04/21	1901.5475
29/04/21	1901.5475
30/04/21	1901.5475

The descriptive statistics, summary of the applied ANN model, residual analysis, in-sample forecasts as well as out-of-sample forecasts are shown in table 1, table 2, figure 1, figure 2 and well as figure 3 and table 3, respectively. The applied forecasting model is stable and acceptable as indicated in the residual analysis. The results of the study basically indicate that daily COVID-19 cases in Costa Rica will reach an equilibrium level of approximately 1901 cases per day around January 12, 2021 and this is likely to persist throughout the rest of the out-of-sample period.

CONCLUSION & RECOMMENDATIONS

While COVID-19 is rapidly propagating around the globe, the need for providing real-time forecasts of the epidemics pushes fits of dynamical and statistical models to available data beyond their capabilities (Alberti & Faranda, 2020). Based on 240 daily observations of COVID-19 cases in Costa Rica, this study used the ANN (12, 12, 1) model to come up with forecasts ranging over the period November 2020 to April 2021. The study established that the pandemic will not end anytime soon in Costa Rica, and that daily cases will remain significantly high. The government of Costa Rica should ensure the continued compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so on. This is expected to play a pivotal role, especially in avoiding extremely catastrophic daily COVID-19 case volumes in the country.

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