PREDICTION OF COVID-19 CASES IN PERU USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Since December 2019, the whole world has been "captured" by COVID-19. Peru, just like other Latin American countries, has not been able to escape from the deadly pandemic. Here, the ANN approach was applied to analyze COVID-19 case volumes for all age groups in Peru. The employed data covers the period March – October 2020 and the out-of-sample period ranges over the period November 2020 – April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of this model indicate that the model is quite stable. The results of the study indicate that daily COVID-19 cases will continue to decline over the out-of-sample period until an equilibrium level of about 104 cases per day is reached somewhere around 11 January 2021. It is important for the Peruvian government to note that the projected decline in COVID-19 cases is a product of the current prevention and control measures being consistently taken. We therefore encourage the government to continue making sure that these measures are taken seriously, especially by the general public.

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

INTRODUCTION & BRIEF BACKGROUND

COVID-19 originated from Wuhan, China in December 2019. Eventually, the virus has spread to rest of the world (Badillo-Rivera *et al*., 2020). So far there is no vaccine against this deadly and highly infectious disease (Chakraborty & Maity, 2020). In Peru, the first COVID-19 case was officially reported in Lima on March 6, 2020; being a Peruvian with recent travel history to France, Spain and Czech Republic (Acquino & Garrison, 2020). A week later, the President of Peru, His Excellency; Martin Vizcarra; declared a nationwide state of emergency for 15 days in order to reduce the spread of the virus. The virus did not have mercy on Peru, after only two months, the country already had 40459 infections and 1124 deaths. The cases kept on rising exponentially despite the measures that were already taken to contain it (Roman-Gonzalez & Vargas-Cuentas, 2020). This could be attributed to the country's questionable adherence to the pandemic's mitigation measures (Fraser, 2020). A number of COVID-19 related studies have been carried out in the country, for example, Roman-Gonzalez & Vargas-Cuentas (2020), Yanez *et al*. (2020), Villarreyes *et al*. (2020), Astigueta-Perez *et al*. (2020), Raynor *et al*. (2020), Badillo-Rivera *et al*. (2020), Munayco *et al*. (2020) and Velasquez & Lara (2020). Studies related to forecasting the future trends of the pandemic are, however, scanty. To the best of our

knowledge, only Yanez *et al*. (2020 forecasted the number of deaths due to COVID-19 in Lima and Peru using ARIMA models. In order to help the Peruvian government in combating the pandemic, this study attempts to model and forecast daily new COVID-19 cases in the country.

METHODOLOGY

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict COVID-19 cases in Peru. The paper specifically applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. The study is actually based on daily confirmed new COVID-19 cases (reffered to as the PX series in this study) for all age groups in Peru. The data covers the period 6 March – 31 October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this research paper was gathered from the online database of the United States of America's Johns Hopkins University.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
3750.8	3482.0	0.0000	21358.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
3225.0	0.85983	1.4839	4.4968
5% Perc.	95% Perc.	IQ range	Missing obs.
0.0000	9085.9	4506.8	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN PERU

Table 2: ANN model summary

Variable	PX
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	0.159996
MSE	3604082.340515
MAE	1490.999555

Residual Analysis for the ANN model

Figure 1: Residual analysis
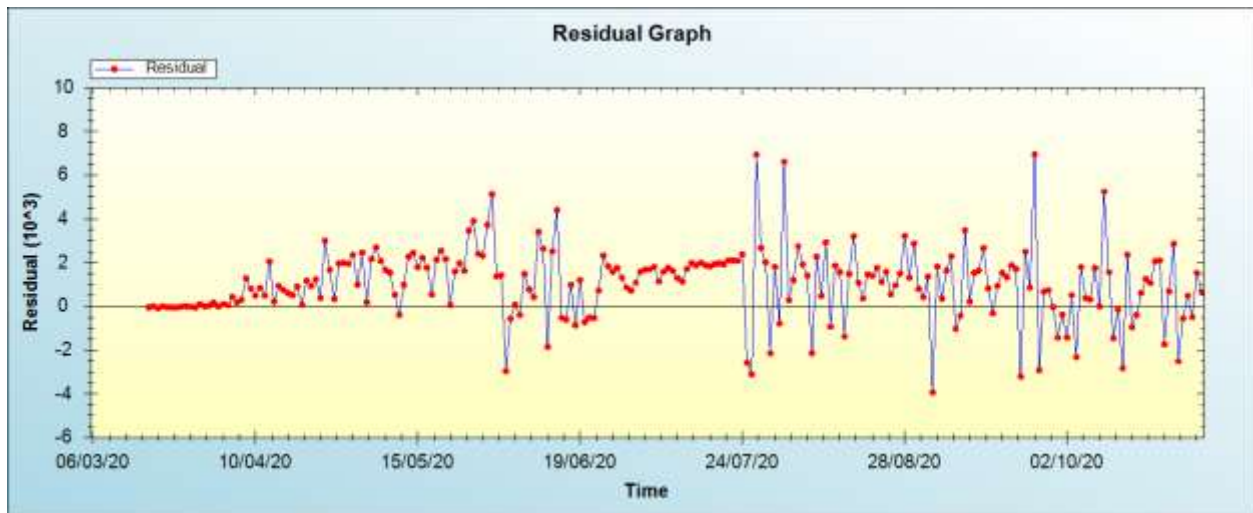
In-sample Forecast for PX

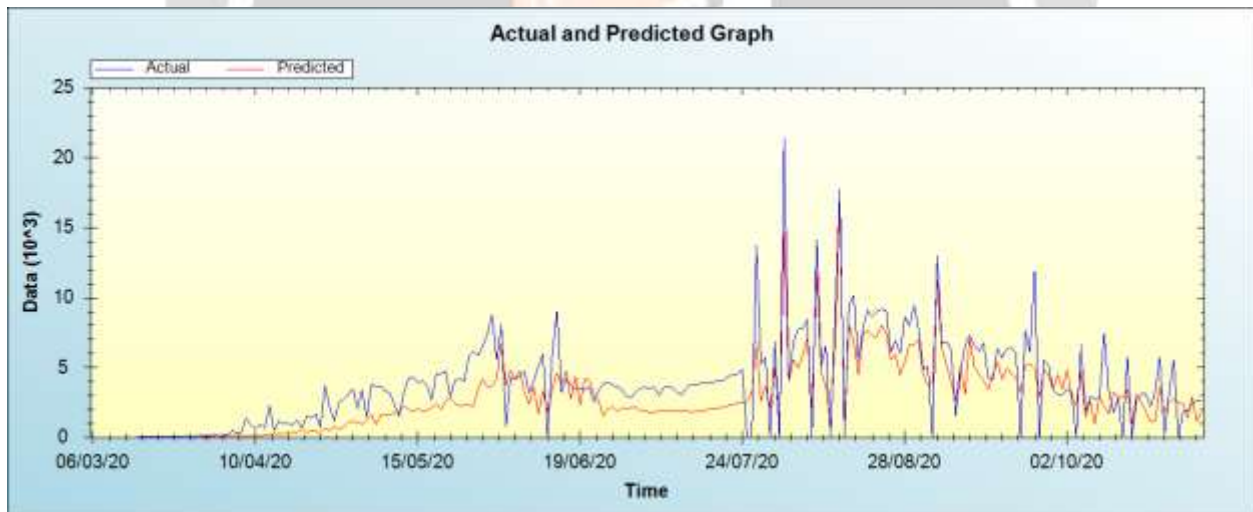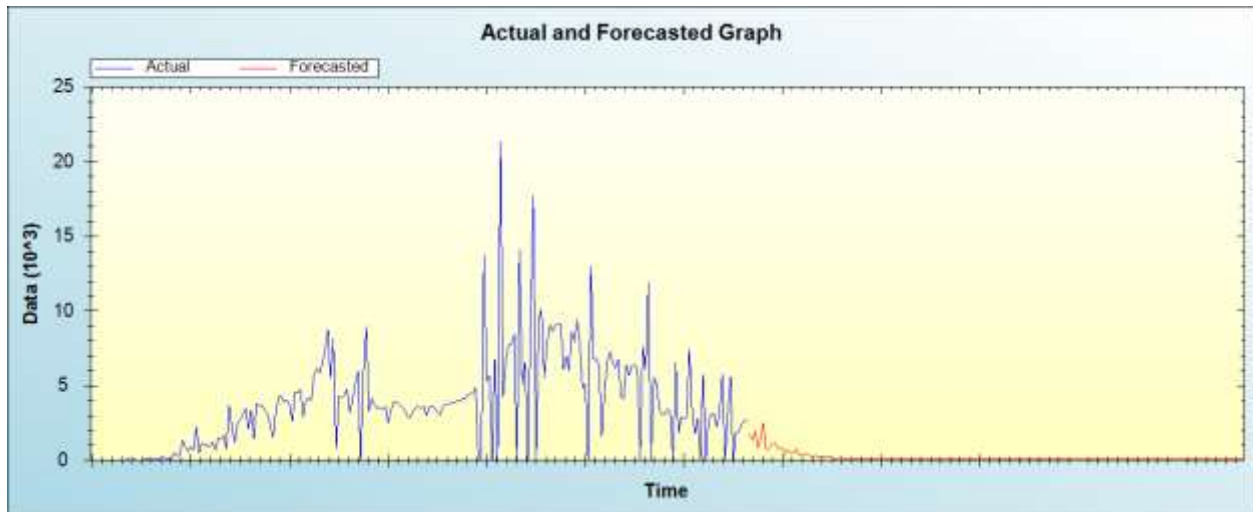Figure 2: In-sample forecast for the PX series

Figure 3 shows the in-sample forecast for PX series.

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

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

Out-of-Sample Forecast for X: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	1780.0555
02/11/20	1360.4036
03/11/20	1975.0010
04/11/20	804.6332
05/11/20	1436.4175
06/11/20	2517.9978
07/11/20	728.1961
08/11/20	774.2689
09/11/20	1030.5595
10/11/20	1245.8806
11/11/20	811.7690
12/11/20	872.5215
13/11/20	871.9756
14/11/20	486.3088
15/11/20	700.7306

16/11/20	490.4602
17/11/20	527.8053
18/11/20	747.0139
19/11/20	349.7695
20/11/20	328.0609
21/11/20	374.8680
22/11/20	445.6928
23/11/20	297.6312
24/11/20	289.5317
25/11/20	327.9340
26/11/20	210.2332
27/11/20	259.6282
28/11/20	227.7917
29/11/20	212.2415
30/11/20	237.4385
01/12/20	178.1320
02/12/20	172.4438
03/12/20	166.9478
04/12/20	186.1072
05/12/20	154.9176
06/12/20	146.1976
07/12/20	157.8653
08/12/20	133.0979
09/12/20	140.8817
10/12/20	135.2405
11/12/20	130.4274

12/12/20	131.2950
13/12/20	123.0222
14/12/20	122.6244
15/12/20	118.2543
16/12/20	122.2703
17/12/20	116.6804
18/12/20	113.7481
19/12/20	116.1190
20/12/20	111.5334
21/12/20	112.4573
22/12/20	111.1413
23/12/20	110.2799
24/12/20	109.7794
25/12/20	108.4400
26/12/20	108.5782
27/12/20	107.2024
28/12/20	107.8881
29/12/20	106.9315
30/12/20	106.2010
31/12/20	106.5683
01/01/21	105.7459
02/01/21	105.8263
03/01/21	105.4738
04/01/21	105.3500
05/01/21	105.1585
06/01/21	104.8903

07/01/21	104.9511
08/01/21	104.6126
09/01/21	104.7074
10/01/21	104.5382
11/01/21	104.3809
12/01/21	104.4197
13/01/21	104.2680
14/01/21	104.2713
15/01/21	104.1776
16/01/21	104.1601
17/01/21	104.1108
18/01/21	104.0503
19/01/21	104.0643
20/01/21	103.9898
21/01/21	103.9990
22/01/21	103.9661
23/01/21	103.9347
24/01/21	103.9346
25/01/21	103.9048
26/01/21	103.9041
27/01/21	103.8806
28/01/21	103.8773
29/01/21	103.8661
30/01/21	103.8521
31/01/21	103.8542
01/02/21	103.8386

02/02/21	103.8386
03/02/21	103.8315
04/02/21	103.8254
05/02/21	103.8239
06/02/21	103.8176
07/02/21	103.8173
08/02/21	103.8117
09/02/21	103.8109
10/02/21	103.8084
11/02/21	103.8052
12/02/21	103.8053
13/02/21	103.8021
14/02/21	103.8018
15/02/21	103.8001
16/02/21	103.7989
17/02/21	103.7983
18/02/21	103.7969
19/02/21	103.7968
20/02/21	103.7955
21/02/21	103.7953
22/02/21	103.7947
23/02/21	103.7940
24/02/21	103.7940
25/02/21	103.7933
26/02/21	103.7932
27/02/21	103.7928

28/02/21	103.7925
01/03/21	103.7924
02/03/21	103.7921
03/03/21	103.7920
04/03/21	103.7917
05/03/21	103.7917
06/03/21	103.7915
07/03/21	103.7914
08/03/21	103.7913
09/03/21	103.7912
10/03/21	103.7912
11/03/21	103.7911
12/03/21	103.7910
13/03/21	103.7910
14/03/21	103.7909
15/03/21	103.7909
16/03/21	103.7908
17/03/21	103.7908
18/03/21	103.7908
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26/04/21	103.7905
27/04/21	103.7905
28/04/21	103.7905
29/04/21	103.7905
30/04/21	103.7905

The average number of daily cases in Peru over the period under study is 3751 cases per day and the maximum over the same period is 21358; as shown in table 1 above. Table 2 is the model summary. Residual diagnostics of the model are presented in figure 1 above. Clearly the model is stable and acceptable for forecasting purposes. Figure 2 shows the in-sample forecasts of the applied model while figure 3 and table 3 present the out-of-sample predictions. We establish that, generally, from November 1, 2020 [1780 cases] – around January 10, 2021 [105 cases], COVID-19 daily cases will be trending downwards in Peru, soon after which an equilibrium case volume of approximately 104 cases will be reached and recorded for the rest of the out-of-sample period.

CONCLUSION & RECOMMENDATIONS

COVID-19 has spread all over the world and Peru has received her share too. In this paper, we applied a basic ANN (12, 12, 1) model. Residual diagnostics of the model used show that the model is stable and acceptable for forecasting COVID-19 cases in Peru. The results of the model indicate that the pandemic may not end anytime soon in the country. While the cases will continue to decline over the out-of-sample period, we note that an equilibrium level of almost 104 cases per day will be reached somewhere around the 11th of January 2021 and this level shall prevail throughout the period January 12, 2020 – April 30, 2020. The Peruvian government is encouraged to continue implementing control and preventive measures until an effective vaccine or treatment is available.

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