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

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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 Spain based on data covering the period February 1, 2020 to October 31, 2020. 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 the applied model reveal that the model is stable in forecasting COVID-19 cases in Spain. The results of the study reveal that daily COVID-19 cases are likely to follow a downwards trajectory characterised by "peaks" and "lows". The model also predicts that by around March 11, 2021, the COVID-19 pandemic would be significantly under control in Spain. Nevertheless, the Spanish 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., in consistency with WHO guidelines on COVID-19 mitigation strategies.

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

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). Available COVID-19 forecasting models for Spain are basically Box-Jenkins models, for example; Ahmar & Val (2020) and Monllor *et al*. (2020) and yet these models are well known for poorly performing when it comes to analyzing non-linear complex data sets such as COVID-19 data. 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 the country.

METHODOLOGY

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections. The research particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. The study is based on daily new covid-19 cases (referred to as S series in this study) for all age groups in Spain. The data covers the period 1 February 2020 to 30 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 John Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
4419.4	884.00	0.00000	52188.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
7191.3	1.6272	2.7655	10.114
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	20172.	6875.0	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN SPAIN

Table 2: ANN model summary

|	
Variable	S
Observations	261 (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	0.061719
MSE	3202052.297488
MAE	1073.870491

Residual Analysis for the ANN model
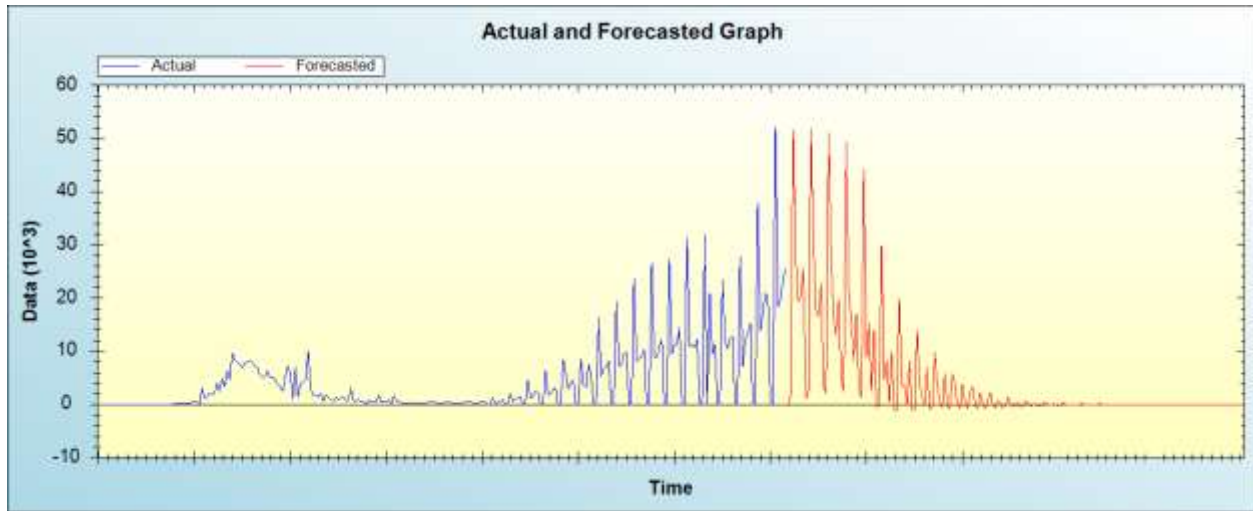
Figure 1: Residual analysis
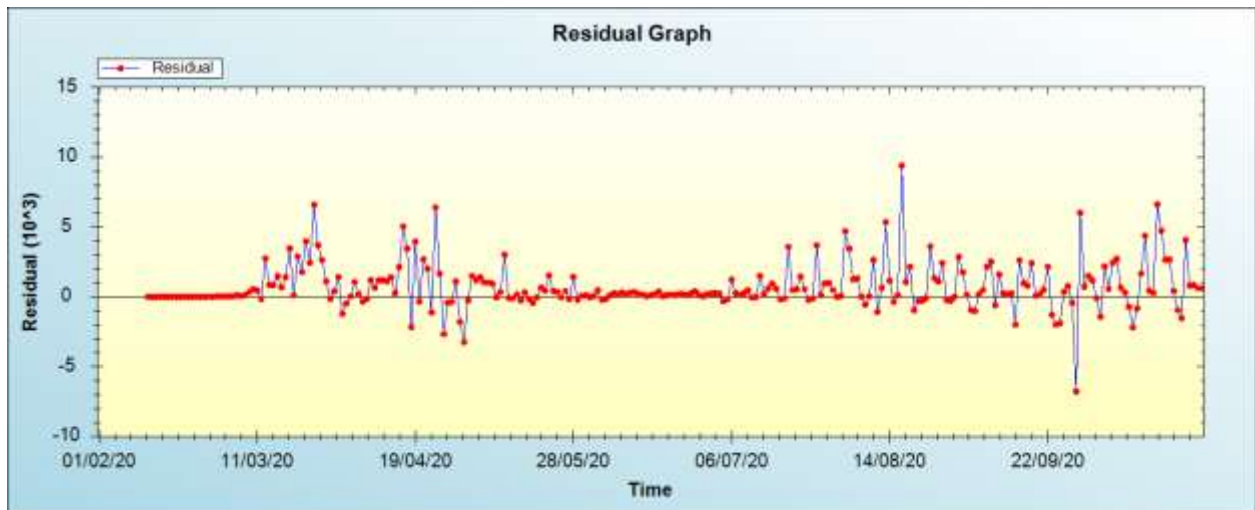
In-sample Forecast for S

Figure 2: In-sample forecast for the S series
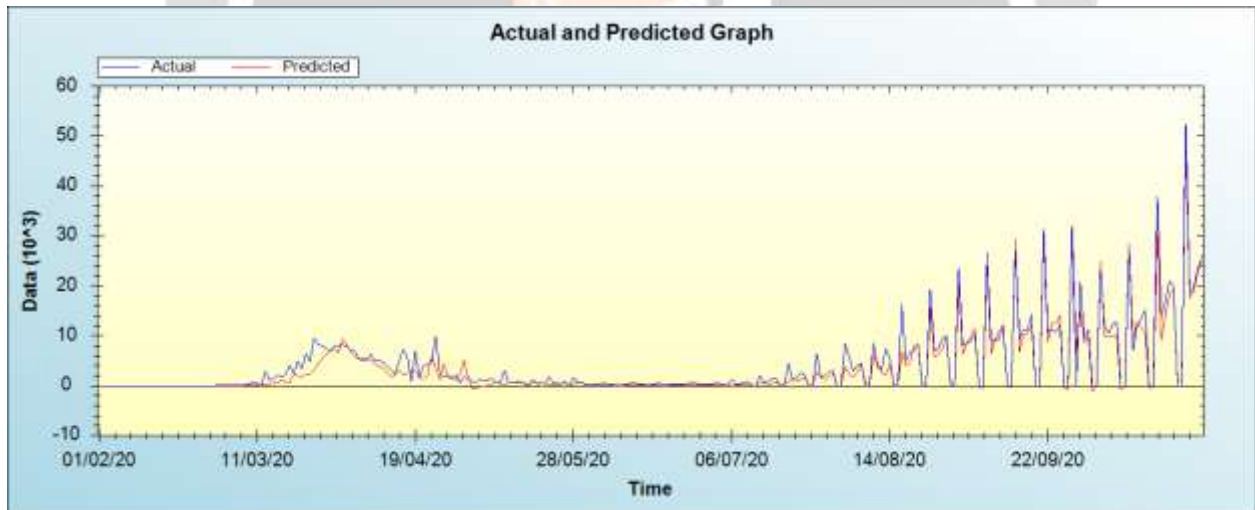
Out-of-Sample Forecast for S: Actual and Forecasted Graph

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	Forecasts
31/10/20	-216.1631
01/11/20	1619.5105
02/11/20	51673.2367
03/11/20	27517.7504
04/11/20	19214.1302
05/11/20	20335.2671
06/11/20	25701.1958
07/11/20	1424.6431
08/11/20	1269.9577
09/11/20	51723.8622
10/11/20	30275.6231
11/11/20	17563.8115
12/11/20	16496.6269

13/11/20	22955.4350
14/11/20	3366.1030
15/11/20	2031.4364
16/11/20	51131.8804
17/11/20	28074.0333
18/11/20	16401.4228
19/11/20	13005.3561
20/11/20	19772.1813
21/11/20	4617.3476
22/11/20	2431.8644
23/11/20	49555.6370
24/11/20	20526.1839
25/11/20	16267.4372
26/11/20	8149.7525
27/11/20	17179.8072
28/11/20	2592.7168
29/11/20	1359.0796
30/11/20	44274.5696
01/12/20	8830.1778
02/12/20	15216.9642
03/12/20	2570.8181
04/12/20	13948.7913
05/12/20	-492.9564
06/12/20	-323.5961
07/12/20	29840.8247
08/12/20	4620.2458

09/12/20	8287.1534
10/12/20	472.1855
11/12/20	10027.1495
12/12/20	-1171.1988
13/12/20	-1128.5733
14/12/20	19922.1333
15/12/20	3646.8562
16/12/20	3780.7905
17/12/20	-145.0211
18/12/20	8188.1101
19/12/20	-1096.5314
20/12/20	-958.6267
21/12/20	14137.2792
22/12/20	3761.0621
23/12/20	1581.4940
24/12/20	-345.3700
25/12/20	7069.6903
26/12/20	-699.7124
27/12/20	-781.5679
28/12/20	9786.4338
29/12/20	3947.8975
30/12/20	566.0838
31/12/20	-528.1957
01/01/21	5743.9920
02/01/21	-263.4954
03/01/21	-760.1717

04/01/21	5814.9373
05/01/21	3893.7545
06/01/21	82.3295
07/01/21	-684.0706
08/01/21	3967.2159
09/01/21	77.7706
10/01/21	-816.0652
11/01/21	2493.3476
12/01/21	3375.7729
13/01/21	-62.9559
14/01/21	-737.7836
15/01/21	2086.1132
16/01/21	295.8907
17/01/21	-814.9491
18/01/21	546.7294
19/01/21	2387.0233
20/01/21	51.4476
21/01/21	-654.9297
22/01/21	740.6958
23/01/21	376.7355
24/01/21	-672.4273
25/01/21	-175.3724
26/01/21	1342.3900
27/01/21	230.2181
28/01/21	-477.2158
29/01/21	108.3026

30/01/21	325.5794
31/01/21	-437.6856
01/02/21	-320.8309
02/02/21	619.0412
03/02/21	307.3316
04/02/21	-279.8240
05/02/21	-88.5630
06/02/21	214.4277
07/02/21	-220.2871
08/02/21	-281.9257
09/02/21	233.2086
10/02/21	273.0750
11/02/21	-123.4083
12/02/21	-113.1975
13/02/21	112.7923
14/02/21	-81.7887
15/02/21	-203.3272
16/02/21	54.8753
17/02/21	190.1256
18/02/21	-29.9319
19/02/21	-89.6515
20/02/21	44.5623
21/02/21	-17.7762
22/02/21	-131.3105
23/02/21	-18.2915
24/02/21	109.1093

25/02/21	10.9326
26/02/21	-60.2893
27/02/21	6.7895
28/02/21	2.0142
01/03/21	-78.5462
02/03/21	-41.3475
03/03/21	50.2681
04/03/21	20.3184
05/03/21	-36.9220
06/03/21	-10.4345
07/03/21	2.9171
08/03/21	-44.9660
09/03/21	-42.2487
10/03/21	14.4774
11/03/21	15.6570
12/03/21	-21.6908
13/03/21	-16.1653
14/03/21	-1.5723
15/03/21	-26.0559
16/03/21	-35.3489
17/03/21	-4.3846
18/03/21	7.1123
19/03/21	-13.4616
20/03/21	-16.6392
21/03/21	-6.1358
22/03/21	-16.7085

23/03/21	-27.4907
24/03/21	-12.8478
25/03/21	-0.7240
26/03/21	-10.0568
27/03/21	-15.3802
28/03/21	-9.3406
29/03/21	-12.8092
30/03/21	-21.2625
31/03/21	-15.7194
01/04/21	-6.4056
02/04/21	-9.3787
03/04/21	-14.0006
04/04/21	-11.2006
05/04/21	-11.6118
06/04/21	-17.1193
07/04/21	-15.9853
08/04/21	-9.9420
09/04/21	-9.9088
10/04/21	-13.0331
11/04/21	-12.1184
12/04/21	-11.5408
13/04/21	-14.6827
14/04/21	-15.2896
15/04/21	-11.8574
16/04/21	-10.7625
17/04/21	-12.5181

18/04/21	-12.4932
19/04/21	-11.8165
20/04/21	-13.4005
21/04/21	-14.4276
22/04/21	-12.7328
23/04/21	-11.5293
24/04/21	-12.3296
25/04/21	-12.6066
26/04/21	-12.1158
27/04/21	-12.8063
28/04/21	-13.7137
29/04/21	-13.0281

The descriptive statistics, architecture of the applied model, residual analysis, in-sample forecasts as well as out-of-sample forecasts are presented in table 1, table 2, figure 1, figure 2 and well as figure 3 and table 3, respectively. The model is stable and acceptable as shown in the residual analysis. The forecasts indicate that daily COVID-19 cases are likely to follow a downwards trajectory characterised by "peaks" and "lows". The model also projects that by around March 11, 2021, the COVID-19 pandemic may come to an end in Spain.

CONCLUSION & RECOMMENDATIONS

Using 273 daily observations of COVID-19 cases in Spain, this study employed the ANN (12, 12, 1) model to come up with forecasts ranging over the period November 2020 to April 2021. The results of the study imply that, generally, the whole out-of-sample period is the beginning of the end of the pandemic. The actual total disappearing of the pandemic in the country is projected to take place sometime during the second week of March 2021. However, the Spanish 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., in consistency with WHO guidelines on COVID-19 mitigation strategies.

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