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

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ABSTRACT

The Artificial Neural Network (ANN) approach was applied in this piece of work, to analyze COVID-19 daily cases in Japan. The employed data covers the period January 15, 2020 to October 31, 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation statistics (Error, MSE and MAE) of the applied model indicate that the model is adequate. The predictions show that daily COVID-19 cases are likely to follow a downwards trajectory throughout the out-of-sample period. However, the government of Japan should ensure the continued compliance to control and preventive COVID-19 measures as outlined by the World Health Organization (WHO).

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

INTRODUCTION

The outbreak in Wuhan, Hubei province, People's Republic of China, in December last year, of a pandemic (dubbed subsequently as COVID-19) that in the next months spread around the world and in some geographical regions was characterized by an abrupt increase in the number of infected individuals, triggered drastic and unprecedented measures of containment since WW2 that affected the life of hundreds of millions of people as well as the normal functioning of numerous national economies (Misucu *et al*., 2020). The first case of COVID-19 in Japan was reported on January 15, 2020 and the number of reported cases has increased day by day (Kuniya, 2020). A state of emergency was declared in Japan on April 7, 2020 and was extended nationwide on April 16, 2020 and ended on May 25, 2020. During this state of emergency people voluntarily self-isolated and no government-enforced lockdown of the districts was implemented (Rashed *et al*., 2020). While a number of COVID-19 related studies have been done in Japan, for example, Sawano *et al* (2020), Rashed *et al*. (2020) and Kuniya (2020), no study has specifically applied Artificial Neural Networks to forecast COVID-19 daily cases in the country. In an attempt to help the Japanese government in taking the most appropriate prevention and control measures for the outbreak, this study seeks to model and forecast confirmed daily 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 in Japan. This 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(referred to as JC series in this study) for all age groups in Japan. The data covers the period 15 January 2020 to 31 October 2020 while the out-of-sample forecast covers the period Novemeber2020 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
348.20	223.00	0.00000	1762.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
374.60	1.0758	1.2449	1.2382
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	1124.0	551.00	0

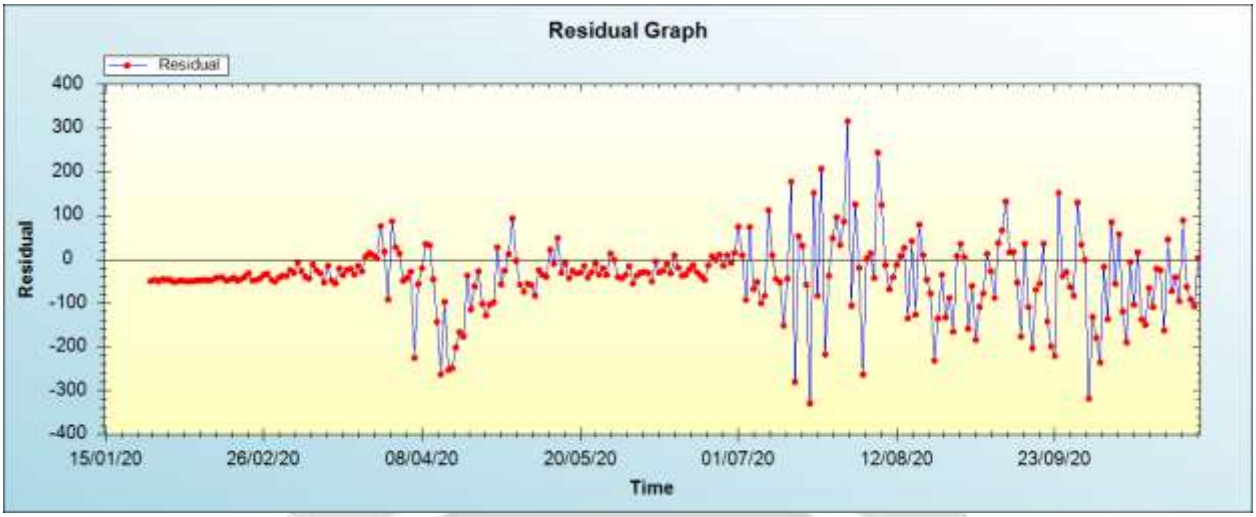
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN JAPAN

Table 2: ANN model summary

Variable	JC
Observations	279 (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	0.094142
MSE	8492.410216
MAE	66.724384

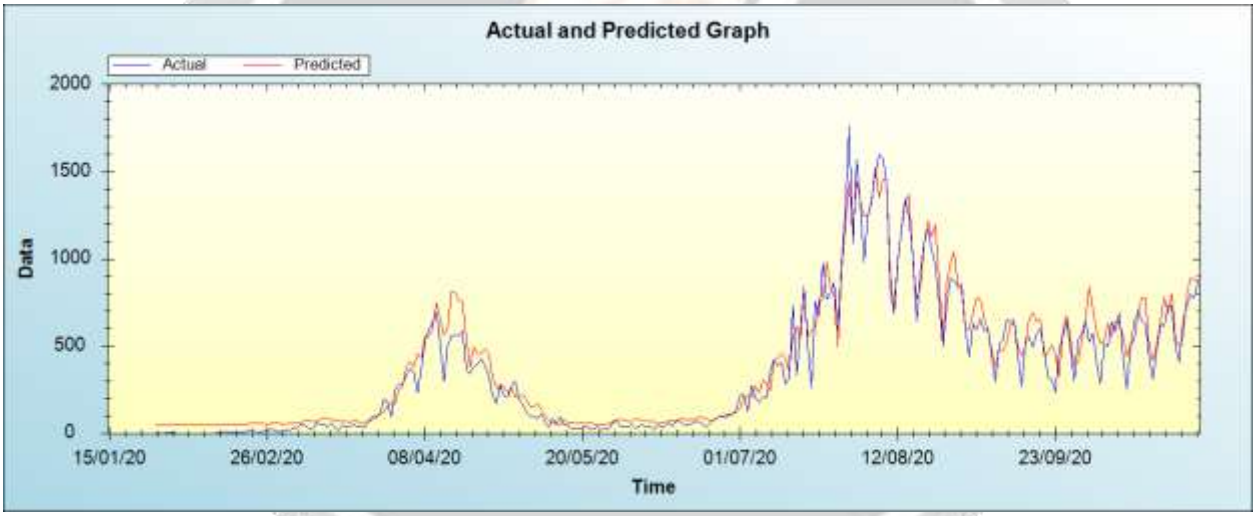
Residual Analysis for the ANN model

Figure 1: Residual analysis



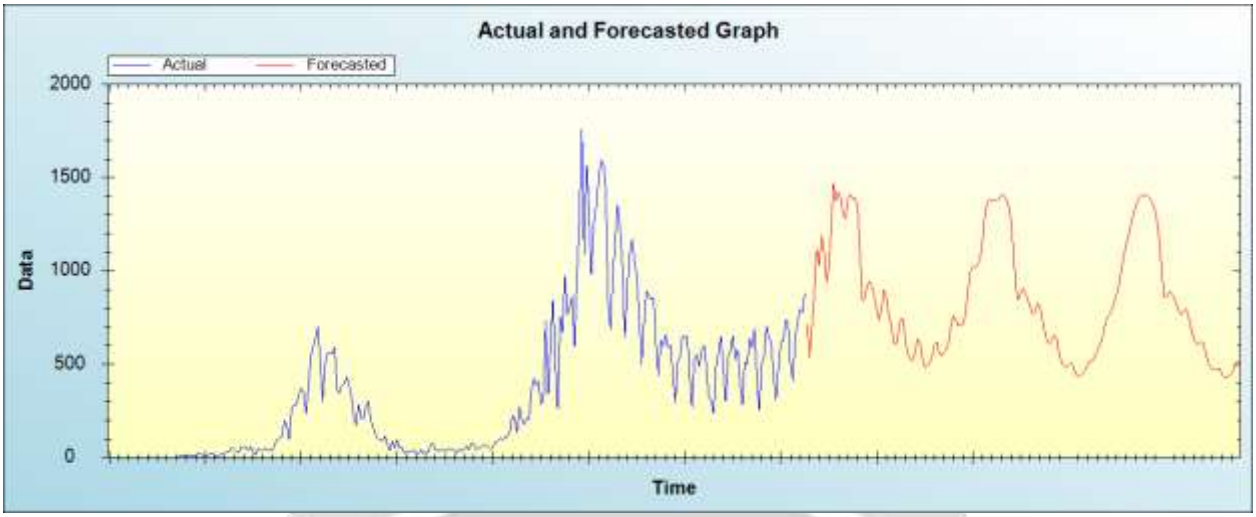
In-sample Forecast for JC

Figure 2: In-sample forecast for the JC series



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

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



Out-of-Sample Forecast for JC: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	716.8495
02/11/20	534.7123
03/11/20	708.2535
04/11/20	882.4455
05/11/20	1121.5836
06/11/20	1027.9536
07/11/20	1193.0020
08/11/20	1105.3796
09/11/20	938.0433
10/11/20	1021.8190
11/11/20	1230.4677
12/11/20	1468.6968
13/11/20	1374.1362
14/11/20	1425.2432
15/11/20	1389.7468

16/11/20	1305.4424
17/11/20	1279.1992
18/11/20	1384.1974
19/11/20	1409.1638
20/11/20	1388.0214
21/11/20	1387.5267
22/11/20	1344.4936
23/11/20	1094.2704
24/11/20	842.1240
25/11/20	855.0485
26/11/20	918.6310
27/11/20	945.1030
28/11/20	915.4927
29/11/20	864.9837
30/11/20	791.3242
01/12/20	738.0566
02/12/20	797.3717
03/12/20	898.8520
04/12/20	863.0911
05/12/20	769.3426
06/12/20	710.8869
07/12/20	613.8790
08/12/20	606.6952
09/12/20	667.7043
10/12/20	745.7077
11/12/20	741.1563

12/12/20	623.7585
13/12/20	553.1001
14/12/20	522.6385
15/12/20	521.4261
16/12/20	570.9173
17/12/20	636.4933
18/12/20	617.9578
19/12/20	531.0848
20/12/20	486.9629
21/12/20	493.0453
22/12/20	505.5564
23/12/20	539.3216
24/12/20	606.8116
25/12/20	617.5663
26/12/20	562.9229
27/12/20	543.2344
28/12/20	564.3135
29/12/20	577.4849
30/12/20	618.6564
31/12/20	709.8591
01/01/21	762.1970
02/01/21	735.7134
03/01/21	706.7351
04/01/21	709.8426
05/01/21	716.0214
06/01/21	771.7728

07/01/21	895.3099
08/01/21	996.3528
09/01/21	1023.6863
10/01/21	1019.0881
11/01/21	1029.9010
12/01/21	1055.6203
13/01/21	1151.4176
14/01/21	1285.8575
15/01/21	1364.4616
16/01/21	1380.3434
17/01/21	1374.4781
18/01/21	1374.2533
19/01/21	1374.3711
20/01/21	1387.8785
21/01/21	1406.3559
22/01/21	1405.4382
23/01/21	1384.5415
24/01/21	1349.9595
25/01/21	1267.9290
26/01/21	1096.4810
27/01/21	910.4334
28/01/21	847.1544
29/01/21	879.8920
30/01/21	904.9129
31/01/21	880.3012
01/02/21	844.5426

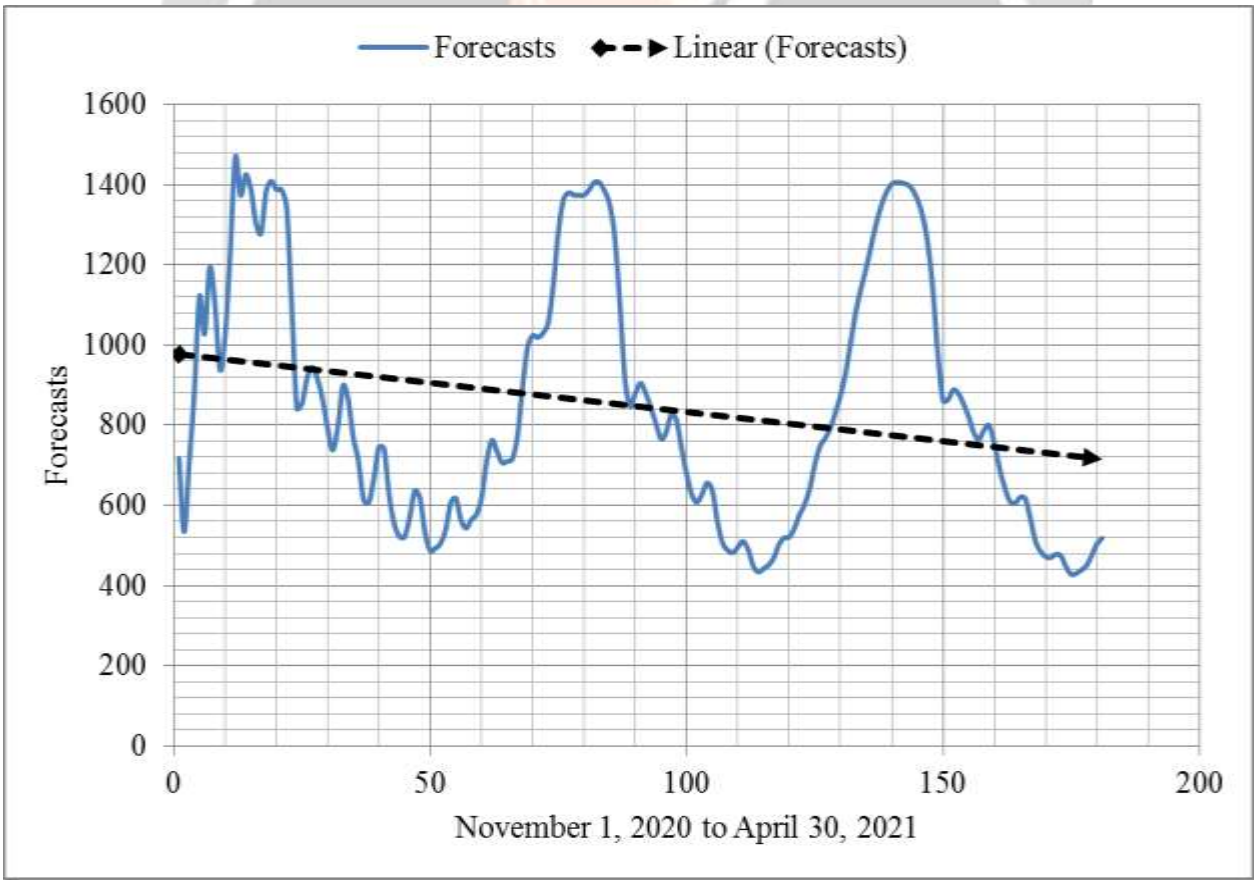
02/02/21	805.0165
03/02/21	765.5887
04/02/21	782.1468
05/02/21	826.8750
06/02/21	813.1130
07/02/21	742.7434
08/02/21	678.0586
09/02/21	626.3407
10/02/21	608.1248
11/02/21	628.1911
12/02/21	656.2207
13/02/21	637.7571
14/02/21	559.4749
15/02/21	506.3149
16/02/21	488.3864
17/02/21	481.8179
18/02/21	495.9949
19/02/21	510.1158
20/02/21	489.0419
21/02/21	447.8986
22/02/21	434.1515
23/02/21	442.3867
24/02/21	451.2461
25/02/21	469.4574
26/02/21	502.2314
27/02/21	518.9669

28/02/21	520.8687
01/03/21	542.8483
02/03/21	576.2552
03/03/21	602.7209
04/03/21	642.4945
05/03/21	703.1927
06/03/21	747.5940
07/03/21	767.2199
08/03/21	792.5764
09/03/21	831.7122
10/03/21	874.5202
11/03/21	931.1099
12/03/21	1007.8685
13/03/21	1083.8932
14/03/21	1141.3824
15/03/21	1191.3435
16/03/21	1249.5042
17/03/21	1305.2933
18/03/21	1349.9567
19/03/21	1382.8363
20/03/21	1401.7758
21/03/21	1406.5350
22/03/21	1404.6827
23/03/21	1400.9010
24/03/21	1388.8981
25/03/21	1363.2788

26/03/21	1322.9083
27/03/21	1255.6126
28/03/21	1137.2931
29/03/21	973.4589
30/03/21	861.3738
31/03/21	864.3169
01/04/21	888.5445
02/04/21	878.8594
03/04/21	853.0677
04/04/21	820.5122
05/04/21	781.2711
06/04/21	764.7502
07/04/21	788.6446
08/04/21	798.9267
09/04/21	753.6733
10/04/21	692.4588
11/04/21	645.0848
12/04/21	610.7358
13/04/21	605.1226
14/04/21	619.9156
15/04/21	617.6316
16/04/21	568.9668
17/04/21	511.4022
18/04/21	485.3664
19/04/21	471.9594
20/04/21	469.8025

21/04/21	478.3834
22/04/21	473.2816
23/04/21	446.0248
24/04/21	427.6813
25/04/21	430.8274
26/04/21	438.6475
27/04/21	450.6235
28/04/21	475.9859
29/04/21	503.5782
30/04/21	518.4283

Figure 4: Graphical presentation of out-of-sample forecasts



The descriptive statistics, summary 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 figures 3 & 4 and table 3, respectively. The applied predictive model is stable and acceptable as

shown in the residual analysis. The forecasts show that daily COVID-19 cases are likely to follow a downwards trajectory characterised by "peaks" and "lows".

CONCLUSION & RECOMMENDATIONS

There is no doubt; COVID-19 has led to excessive healthcare crisis with millions of infected people across the globe often pushing infrastructures, healthcare workers and entire economies beyond their limits. Japan has not been spared by this pandemic and hence the need for forecasting. Based on 291 daily observations of COVID-19 cases in Japan, this study used 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 suggest that the whole out-of-sample period is the beginning of the end of the pandemic. However, the government of Japan 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 will help a lot, particularly in avoiding extremely regrettable daily COVID-19 case volumes in the country.

REFERENCES

[1] COVID-19 Repository By the Center for Systems Science and Engineering (CSSE) at Johns Hopkins University.

[2] Dong, E., *et al*. (2020). An Interactive Web-based Dashboard to Track COVID-19 in Real Time, *Lancet Infectious Diseases*, 20 (5): 533 – 534.

[3] Kuniya, T. (2020). Prediction of the Epidemic Peak of Coronavirus Disease in Japan, 2020, *Journal of Clinical Medicine*, 9 (789): 1 – 7.

[4] Misicu, S., *et al*. (2020). Beginning of the End of the Pandemic? A Comparison Between Italy and Romania, *medRxiv*, pp: 1 – 6.

[5] Rashed, E. A., *et al*. (2020). Influence of Absolute Humidity, Temperature and Population Density on COVID-19 Spread and Decay Durations: Multi-prefecture Study in Japan, *International Journal of Environmental Research and Public Health*, 17 (5354): 1 – 14.

[6] Sawano, T., *et al*. (2020). Limiting Spread of COVID-19 From Cruise Ships: Lessons to be Learnt From Japan, *QJM: An International Journal of Medicine*, 113 (5): 309 – 310.