PREDICTION OF COVID-19 CASES IN THE CZECH REPUBLIC USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Since COVID-19 is a serious global public health threat, different researchers around the globe are busy trying to come up with predictive models that can reliably explain its current and future transmission and evolution dynamics. In this paper, the ANN approach was applied to analyze daily COVID-19 cases in the Czech Republic. The employed data covers the period March 1, 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 criteria (Error, MSE and MAE) of our model apparently suggest that the model is indeed stable. The results of the study suggest that the pandemic is likely to remain highly prevalent in the Czech Republic over the period November 2020 to April 2021. The government of the Czech Republic should continue implementing all sanitary rules in line with WHO standards and also plan ahead in terms of allocating adequate resources to hospitals, especially in intensive care units.

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

INTRODUCTION

Having started in Wuhan, China, in late December 2019 (Hernandez-Matamoros *et al*., 2020), COVID-19 is an infectious disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Katris, 2020). The first case outside of China was reported in Thailand on January 13, 2020 (Hui *et al*., 2020). Since then, this ongoing outbreak has spread to the rest of the world. The symptoms of COVID-19 infection include fever, cough, shortness of breath, and diarrhoea. In more severe cases, COVID-19 can cause pneumonia and even death (WHO, 2020). COVID-19 eruption has not only disrupted the global healthcare networks but also it has demised the world economy (Hazarika & Gupta, 2020). In the Czech Republic, the first 3 cases of COVID-19 infection were officially confirmed on March 1, 2020; in line with the country's Public Health Protection Act and the Act on the Security of the Czech Republic, early public health interventions followed almost 2 weeks later (Komenda *et al*., 2020; Majek *et al*., 2020). Forecasting is a very essential (Fong *et al*., 2020) and yet challenging task (Rizk-Allah & Hassanien, 2020), especially for COVID-19. Accurate modelling and future forecast of daily number of confirmed COVID-19 cases can help the treatment system in providing services for the new patients (Katris, 2020). In this paper, we seek to model and forecast COVID-19 cases in the Czech Republic using Artificial Neural Networks (ANNs).

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 the Czech Republic. The study particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. The research is based on daily new Covid-19 cases (referred to as RC series in this study) in all age groups in the Czech Republic. The data covers the period 1 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
1367.8	149.00	0.00000	15663.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
3165.3	2.3142	2.9960	8.2636
5% Perc.	95% Perc.	IQ range	Missing obs.
18.000	10107.	440.00	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN THE CZECH REPUBLIC

Table 2: ANN model summary

| Variable	RC
Observations	233 (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	0.040646
MSE	125096.8O4782
MAE	188.670510

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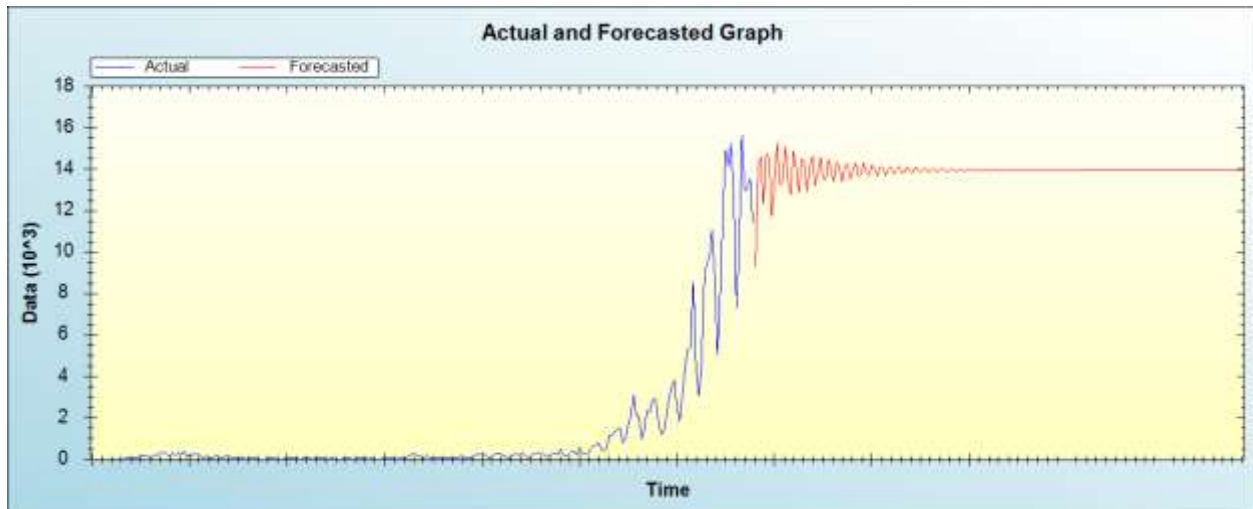
Figure 1: Residual analysis
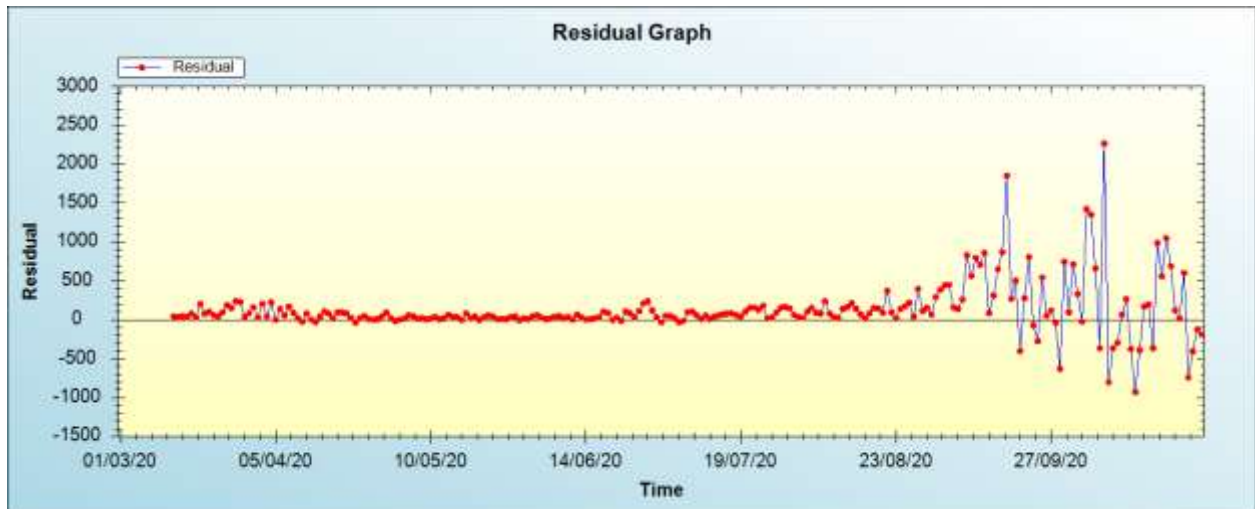
In-sample Forecast for RC

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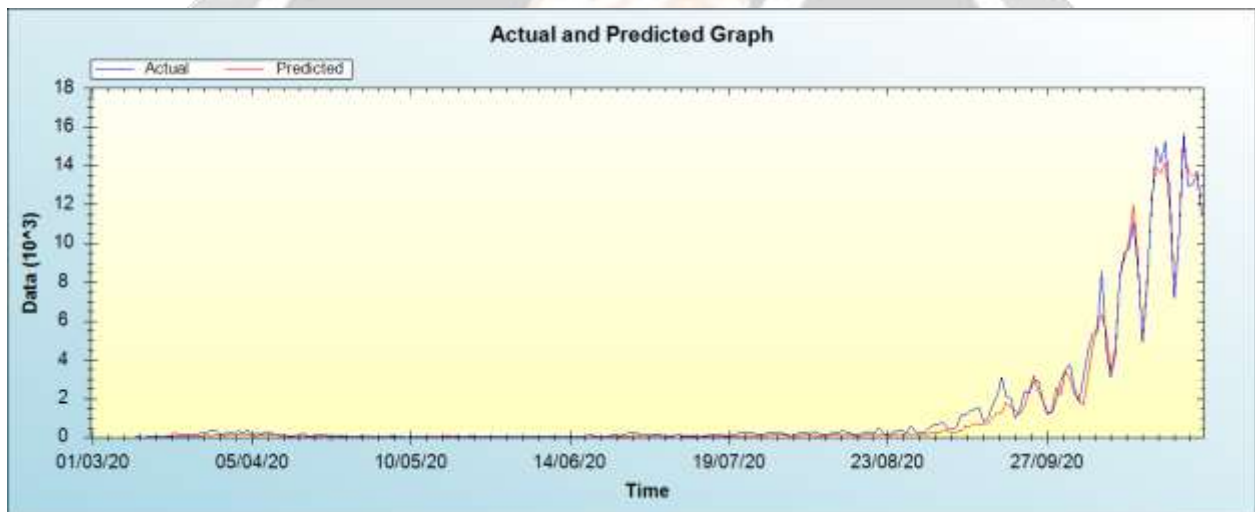
Out-of-Sample Forecast for RC: Actual and Forecasted Graph

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

Actual and Forecasted Graph

Out-of-Sample Forecast for RC: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	9317.7624
02/11/20	14173.9555
03/11/20	14597.6306
04/11/20	12294.5624
05/11/20	14761.1661
06/11/20	14521.5451
07/11/20	11749.5083
08/11/20	13323.7137
09/11/20	15304.4397
10/11/20	13267.5428
11/11/20	13429.1608
12/11/20	15117.3392
13/11/20	13421.8789
14/11/20	12778.1458

15/11/20	14863.5865
16/11/20	14168.3582
17/11/20	12878.9027
18/11/20	14472.3974
19/11/20	14408.2933
20/11/20	12900.2343
21/11/20	14063.0527
22/11/20	14628.8010
23/11/20	13224.5611
24/11/20	13756.6285
25/11/20	14606.0860
26/11/20	13555.5995
27/11/20	13498.6344
28/11/20	14536.1702
29/11/20	13893.9086
30/11/20	13394.2790
01/12/20	14365.0187
02/12/20	14127.4609
03/12/20	13397.7490
04/12/20	14165.4604
05/12/20	14268.4869
06/12/20	13510.3061
07/12/20	13954.5389
08/12/20	14322.4670
09/12/20	13663.7410
10/12/20	13795.0903

11/12/20	14304.9066
12/12/20	13833.9737
13/12/20	13697.6082
14/12/20	14233.3581
15/12/20	13977.6309
16/12/20	13671.2390
17/12/20	14128.3827
18/12/20	14084.1318
19/12/20	13697.1608
20/12/20	14017.8960
21/12/20	14139.3729
22/12/20	13763.6459
23/12/20	13920.4109
24/12/20	14151.4606
25/12/20	13846.1668
26/12/20	13852.2946
27/12/20	14126.5147
28/12/20	13928.8757
29/12/20	13817.1167
30/12/20	14079.8072
31/12/20	13994.7643
01/01/21	13815.4449
02/01/21	14022.0457
03/01/21	14038.5357
04/01/21	13838.3095
05/01/21	13966.8776

06/01/21	14057.1971
07/01/21	13876.9009
08/01/21	13922.2590
09/01/21	14054.9017
10/01/21	13919.5791
11/01/21	13894.6286
12/01/21	14036.1512
13/01/21	13958.7530
14/01/21	13884.1617
15/01/21	14008.6032
16/01/21	13987.9382
17/01/21	13889.2099
18/01/21	13978.4972
19/01/21	14005.1072
20/01/21	13904.7029
21/01/21	13952.0659
22/01/21	14009.8417
23/01/21	13925.8313
24/01/21	13932.6931
25/01/21	14004.6545
26/01/21	13947.2594
27/01/21	13922.3708
28/01/21	13992.5396
29/01/21	13965.4547
30/01/21	13920.5413
31/01/21	13977.4143

01/02/21	13977.8703
02/02/21	13925.6929
03/02/21	13962.4174
04/02/21	13983.9356
05/02/21	13935.1152
06/02/21	13950.2419
07/02/21	13984.0154
08/02/21	13946.2650
09/02/21	13942.2261
10/02/21	13979.6260
11/02/21	13956.7041
12/02/21	13938.8645
13/02/21	13972.5012
14/02/21	13964.8805
15/02/21	13939.5647
16/02/21	13964.5797
17/02/21	13969.8711
18/02/21	13943.2928
19/02/21	13957.3648
20/02/21	13971.6301
21/02/21	13948.6346
22/02/21	13951.9774
23/02/21	13970.5887
24/02/21	13954.3169
25/02/21	13948.8821
26/02/21	13967.6249

27/02/21	13959.2483
28/02/21	13948.0964
01/03/21	13963.6817
02/03/21	13962.7817
03/03/21	13949.1850
04/03/21	13959.6913
05/03/21	13964.6244
06/03/21	13951.5297
07/03/21	13956.3376
08/03/21	13964.8780
09/03/21	13954.4115
10/03/21	13954.0612
11/03/21	13963.8663
12/03/21	13957.2156
13/03/21	13952.9889
14/03/21	13962.0746
15/03/21	13959.4678
16/03/21	13953.0275
17/03/21	13959.9898
18/03/21	13960.9188
19/03/21	13953.8988
20/03/21	13958.0476
21/03/21	13961.5042
22/03/21	13955.2591
23/03/21	13956.5441
24/03/21	13961.3342

25/03/21	13956.7524
26/03/21	13955.6386
27/03/21	13960.6146
28/03/21	13958.0928
29/03/21	13955.3417
30/03/21	13959.6034
31/03/21	13959.0827
01/04/21	13955.5622
02/04/21	13958.5421
03/04/21	13959.6373
04/04/21	13956.1366
05/04/21	13957.6277
06/04/21	13959.7631
07/04/21	13956.8829
08/04/21	13956.9815
09/04/21	13959.5420
10/04/21	13957.6301
11/04/21	13956.6524
12/04/21	13959.0938
13/04/21	13958.2500
14/04/21	13956.6205
15/04/21	13958.5508
16/04/21	13958.6652
17/04/21	13956.8213
18/04/21	13958.0286
19/04/21	13958.8536

20/04/21	13957.1641
21/04/21	13957.6129
22/04/21	13958.8363
23/04/21	13957.5563
24/04/21	13957.3496
25/04/21	13958.6657
26/04/21	13957.9180
27/04/21	13957.2482
28/04/21	13958.4075
29/04/21	13958.1944
30/04/21	13957.2872

The descriptive statistics shown in table 1 above indicate that the average number of daily cases over the study period was 1368 while the maximum number of daily cases was 15663. These huge numbers call for drastic action in the country. Table is the summary of ANN model applied while figure 1 presents its diagnostics; which, of course, confirm its stability. Figure 2 shows the in-sample forecasts of the model employed while figure 3 and table 3 display out-of-sample predictions. Our results indicate that daily COVID-19 cases will remain very high in the out-of-sample, largely around 13900 cases per day.

CONCLUSION & RECOMMENDATIONS

Researchers around the world, especially medical doctors and health economists; continue to apply various prediction models for COVID-19 to make informed decisions and impose appropriate control meausres. In this piece of work, we used a basic ANN (12, 12, 1) model to analyze COVID-19 daily cases in the Czech Republic. We find that the pandemic is far from ending in the country. We advise the relevant authorities in the Czech Republic to continue strictly enforcing WHO recommended control and prevention measures in order to stop the virus from spreading at an even faster rate.

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