PREDICTION OF DAILY NEW COVID-19 CASES IN GERMANY USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In this piece of work, the ANN approach was applied to analyze daily new COVID-19 cases in Germany. The employed data covers the period 27 January 2020 to 31 October 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 the applied model indicate that the model is stable in forecasting daily new COVID-19 cases in Germany. The results of the study indicate that daily COVI-19 cases are most likely to follow a downwards trajectory over the out-of-sample period. The government of Germany is encouraged to continue implementing non-pharmacological interventions with strict adherence to the recommended WHO guidelines on prevention and control of COVID-19.

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

INTRODUCTION

Germany has been hard hit by the coronavirus disease (COVID-19) and there is growing concern of the increased demand of critical resources which are currently inadequate (Gillmann, 2020). The SARS-CoV-2 (COVID-19) virus is rapidly spreading in the country. As of 17 April, 2020 the RKI reported more than 130,000 confirmed cases and about 4000 COVID-19 deaths. The government of Germany responded to the epidemic by implementing measures which included lockdown, social distancing measures, wearing of face masks, hygiene practices, testing and treatment of cases, and isolation of COVID-19 positive patients. In addition to that elective surgical operations and non -emergency admissions were postponed (Martin et al., 2020; Cowan et al., 2020; Wagner et al., 2020c). Healthcare challenges brought by the pandemic include increasing hygiene measures in oncology and other medical units, more complicated and difficult treatment procedures aggravated by facial masks and personal protective equipment (Filippi et al., 2020) and increasing number of healthcare workers and ancillary staff who fall sick there by hampering efforts to secure continuous patient care (Stephanie et al., 2020). COVID-19 virus is transmitted from person to person via droplets produced by sneezing, coughing and talking and through touching contaminated objects or surfaces (RKI, 2020; WHO, 2020; CDC, 2020).The virus has an incubation period of 2-14days. The clinical symptoms of the disease include headache, fever, cough, sore-throat, chest pains, muscle pains and shortness of breath. Multi-organ failure may occur in severe cases (RKI, 2020; WHO, 2020). Severe disease and death are more common in the elderly or patients with underlying chronic medical conditions. However,

severe illness and death can still occur in the young and healthy individuals (WHO, 2020; Rothe et al, 2020; Epicentro, 2020). Empirical studies on COVID-19 are not so many in Germany. Barbarossa et al (2020) did modeling of the spread of COVID-19 in Germany and the modified SEIR model was applied. Findings of the study indicate that partial (gradual) lifting of introduced control measures could be soon be possible if accompanied by further increase in testing activity, strict isolation of detected cases and reduced contacts to risk groups. In this paper we applied the ANN (Multilayer Perceptron) to model and forecast the number of daily new COVID-19 cases in Germany. The findings of this study are expected to stimulate an evidence-based National Response to the COVID-19 epidemic in order to save lives.

METHOD

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily COVID-19 infections in Germany. The particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function.

Data Issues

This study is based on daily new Covid-19 cases (referred to as L series in this study) in all age groups in Germany. The data covers the period 27 January 2020 to 31October 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
1906.1	839.00	0.00000	23553.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
3120.5	1.6372	3.8273	18.658
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	7173.0	1567.0	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN GERMANY

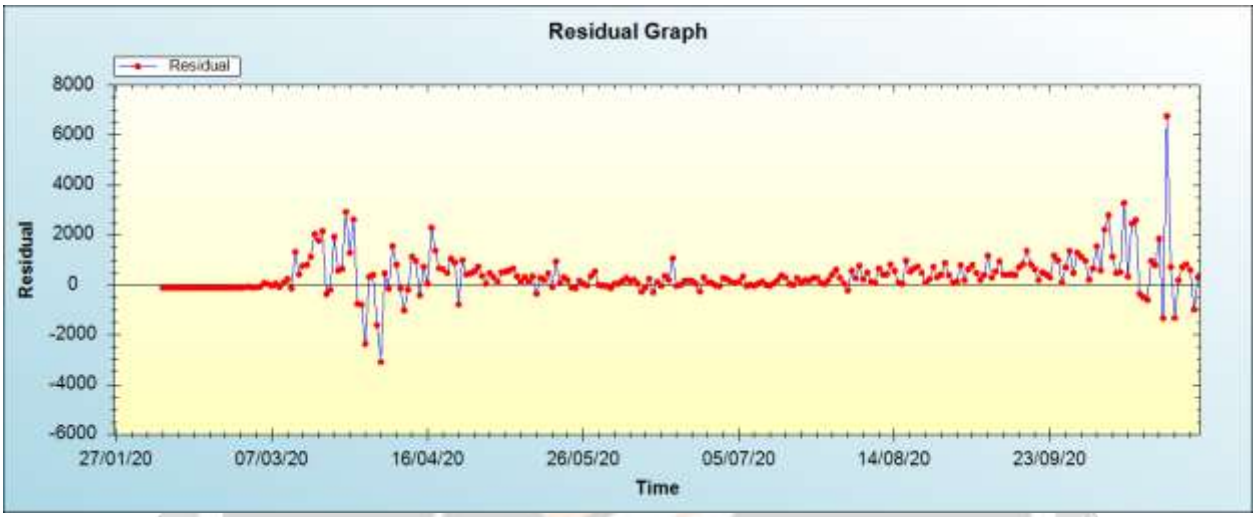
Table 2: ANN model summary

Variable	L
Observations	267 (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	0.068014
MSE	792040.083602
MAE	541.678423

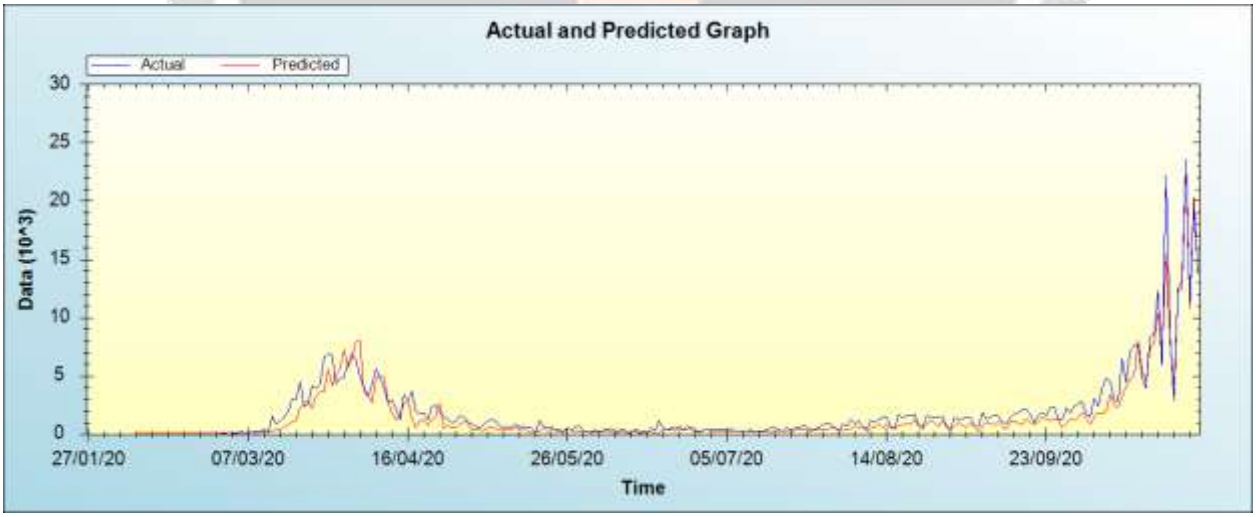
Residual Analysis for the ANN model

Figure 1: Residual analysis



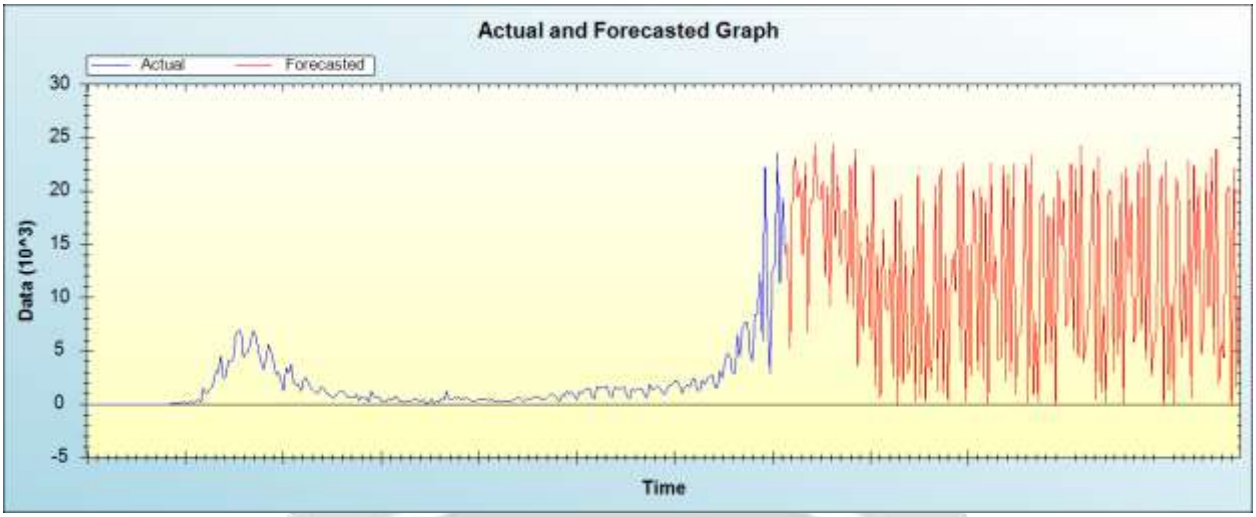
In-sample Forecast for L

Figure 2: In-sample forecast for the L series



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

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



Out-of-Sample Forecast for L: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasted number of daily new COVID-19cases
01/11/20	15059.9040
02/11/20	5261.6632
03/11/20	21461.3276
04/11/20	23063.7985
05/11/20	19348.8948
06/11/20	21083.9967
07/11/20	13953.3047
08/11/20	22657.9858
09/11/20	6737.7893
10/11/20	19109.7522
11/11/20	18982.7953
12/11/20	24352.9049
13/11/20	19432.6884
14/11/20	19111.3552

15/11/20	20929.4846
16/11/20	11944.1205
17/11/20	20407.5900
18/11/20	9231.0262
19/11/20	24429.6393
20/11/20	15531.0390
21/11/20	21510.2848
22/11/20	13108.9642
23/11/20	17839.5014
24/11/20	18250.0634
25/11/20	9451.3211
26/11/20	22354.4065
27/11/20	9052.3275
28/11/20	23947.6547
29/11/20	3500.0355
30/11/20	15281.7395
01/12/20	6838.0376
02/12/20	11380.4603
03/12/20	16831.5496
04/12/20	6037.7059
05/12/20	22391.4081
06/12/20	1659.7424
07/12/20	13988.4079
08/12/20	593.4559
09/12/20	16497.8969
10/12/20	9159.3201

11/12/20	8771.6727
12/12/20	13849.1053
13/12/20	2501.7475
14/12/20	19221.1460
15/12/20	-137.7754
16/12/20	19639.8011
17/12/20	1884.2973
18/12/20	14395.5474
19/12/20	2836.9819
20/12/20	4864.1863
21/12/20	14674.6956
22/12/20	269.1849
23/12/20	21458.1134
24/12/20	644.0066
25/12/20	19129.8694
26/12/20	161.4241
27/12/20	9289.4616
28/12/20	2309.3038
29/12/20	5283.1418
30/12/20	20562.4254
31/12/20	1193.1487
01/01/21	22160.5985
02/01/21	973.9821
03/01/21	13957.9409
04/01/21	183.6501
05/01/21	10874.2474

06/01/21	14087.0888
07/01/21	10535.8166
08/01/21	21869.0961
09/01/21	3984.7432
10/01/21	22626.3518
11/01/21	183.0995
12/01/21	14900.6855
13/01/21	2698.5980
14/01/21	20085.7296
15/01/21	17876.1897
16/01/21	3077.4290
17/01/21	20355.5770
18/01/21	2338.7151
19/01/21	19095.1258
20/01/21	50.8450
21/01/21	22617.4607
22/01/21	10451.0116
23/01/21	13935.2400
24/01/21	4126.2713
25/01/21	4401.1886
26/01/21	22381.6786
27/01/21	2182.5900
28/01/21	21688.0475
29/01/21	3062.9873
30/01/21	22554.3052
31/01/21	914.6738

01/02/21	6424.6827
02/02/21	6616.0547
03/02/21	11615.5747
04/02/21	22547.6696
05/02/21	160.0358
06/02/21	23390.5623
07/02/21	839.7588
08/02/21	7773.6009
09/02/21	251.6913
10/02/21	19014.8114
11/02/21	19809.6226
12/02/21	3812.2447
13/02/21	17750.7083
14/02/21	3844.0820
15/02/21	19291.4898
16/02/21	-141.7944
17/02/21	21970.8117
18/02/21	14911.9759
19/02/21	19167.4812
20/02/21	7248.6416
21/02/21	8237.1526
22/02/21	22550.9796
23/02/21	5065.6205
24/02/21	22122.7014
25/02/21	4345.9305
26/02/21	24297.7213

27/02/21	3931.2112
28/02/21	5398.7104
01/03/21	8053.8838
02/03/21	16403.3107
03/03/21	22004.1333
04/03/21	360.6763
05/03/21	23157.4545
06/03/21	1062.9472
07/03/21	9127.4582
08/03/21	155.6240
09/03/21	20162.3152
10/03/21	19826.4677
11/03/21	3077.4418
12/03/21	15698.4959
13/03/21	4637.9912
14/03/21	21661.1242
15/03/21	46.9502
16/03/21	22173.7914
17/03/21	12418.3064
18/03/21	18954.9817
19/03/21	5769.5337
20/03/21	6887.6569
21/03/21	22594.8237
22/03/21	6860.2249
23/03/21	22689.8025
24/03/21	4187.0229

25/03/21	24022.0193
26/03/21	2608.6177
27/03/21	5649.9447
28/03/21	6009.2842
29/03/21	18132.5589
30/03/21	21506.2572
31/03/21	-142.7681
01/04/21	22780.4414
02/04/21	1257.8988
03/04/21	9493.2281
04/04/21	25.5706
05/04/21	21207.9691
06/04/21	19681.0841
07/04/21	4478.2237
08/04/21	13064.5558
09/04/21	6021.9140
10/04/21	22876.8724
11/04/21	613.7797
12/04/21	22359.3604
13/04/21	11129.7586
14/04/21	20458.0392
15/04/21	4746.4886
16/04/21	7327.5123
17/04/21	21721.1410
18/04/21	9036.7304
19/04/21	23206.1116

20/04/21	4618.0559
21/04/21	23959.2351
22/04/21	1924.6577
23/04/21	5851.8839
24/04/21	4351.3723
25/04/21	19814.9915
26/04/21	20419.7001
27/04/21	-180.9173
28/04/21	22151.3563
29/04/21	1545.2907
30/04/21	9866.0026

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

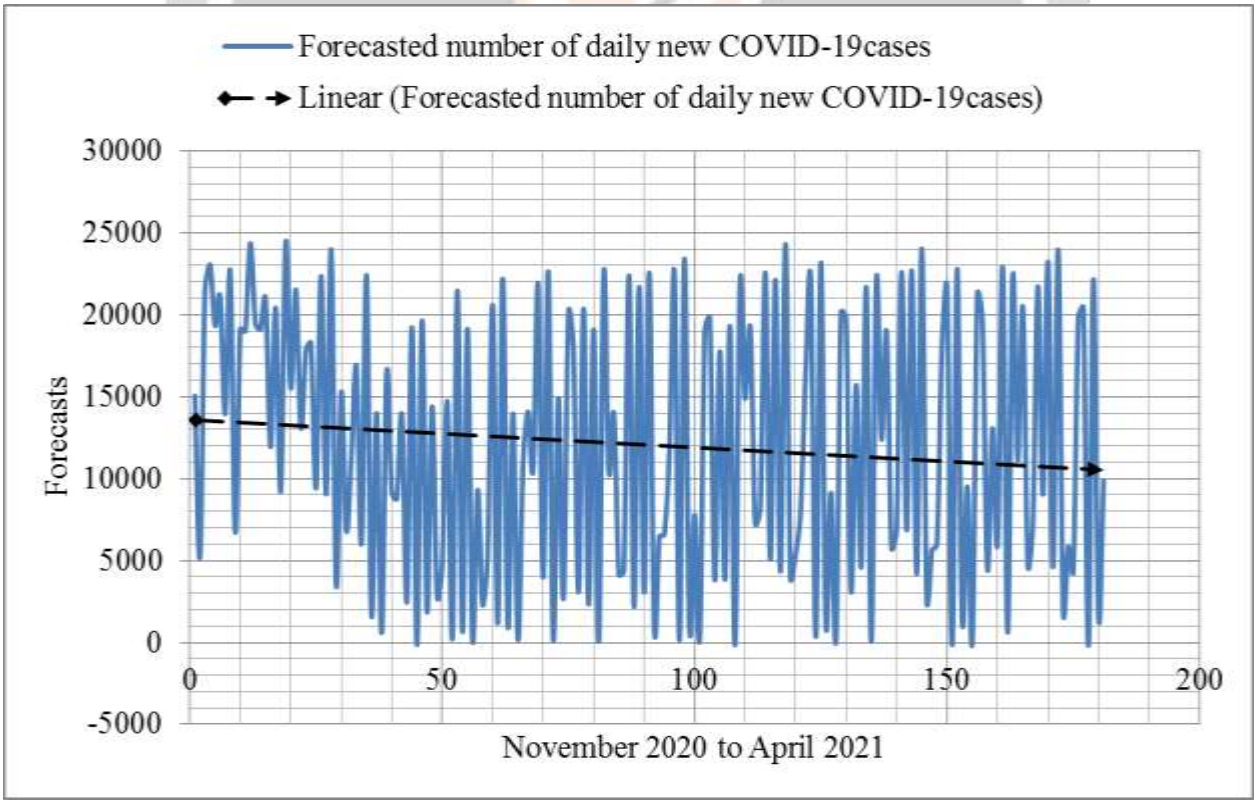


Figure 1 shows that over the study period the minimum and maximum numbers of daily new COVID-19 cases are 0 and 23 553 cases respectively. The data is not normally distributed as it is positively skewed with a kurtosis value of 18. 658. The in-sample forecasts show that the applied model simulates observed values very well and on the other hand the model evaluation statistics

and residual graph indicate that the ANN (12,12,1) model is stable and suitable for forecasting daily new COVID-19 cases in Germany. The results of the study indicate that COVID-19 cases will generally decline in the out-of-sample period.

CONCLUSION & RECOMMENDATIONS

The health delivery system in Germany is overwhelmed by the increased demand of critical care resources which is aggravated by dwindling financial resources associated with the Global economic meltdown. Many health workers have fallen sick or even died from the virus. An effective solution to this ferocious problem will be solved by an effective vaccine which must be availed in time to minimize morbidity and mortality. Meanwhile, non-pharmacological interventions must be implemented with strict adherence to the recommended WHO guidelines on prevention and control of COVID-19. An effective and safe coronavirus vaccine is the solution to the COVID-19 pandemic and if availed to the majority of citizens daily new cases are expected to drop drastically in the out-of sample period.

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