

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

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ABSTRACT

As COVID-19 rages throughout the world, reliable modeling and forecasting of the dynamics thereof is fundamental. In this research work, the ANN technique was applied to forecast daily COVID-19 cases in Turkey. The employed data covers the period March 11, 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 the employed model suggest that the model is stable. The results of the study generally suggest that within the next 6 months beginning from November 1, 2020; daily new COVID-19 cases will most likely follow a downwards trajectory. We also project that around March 1, 2021, this trajectory could be interjected by a characteristic equilibrium level of approximately 753 cases per day for the rest of the out-of-sample period. We, however, still; strongly recommend that the government of Turkey should continue to ensure strict adherence to lock-down measures while creating awareness about the COVID-19 pandemic. We also urge everyone in the country to be more responsible, especially with regards to social distancing, washing of hands and wearing of masks.

Keywords: - ANN, COVID-19, Forecasting

INTRODUCTION

In mid to late December 2019, Chinese authorities in Wuhan reported a novel pneumonia caused by a corona virus disease (now COVID-19) which has spread domestically and internationally since then (Huang *et al.*, 2020; Zhu *et al.*, 2020). COVID-19 is highly infectious and its main clinical symptoms fever, fatigue or myalgia, dry cough and shortness of breath or difficulty breathing (Sohrabi *et al.*, 2020; Nicola *et al.*, 2020; Tian *et al.*, 2020; Wang *et al.*, 2020). Due to fast transmission of COVID-19, the incidence and mortality rates are rapidly growing worldwide (Guan *et al.*, 2020). With the rapid spread of the COVID-19 outbreak, people have been highly concerned by its spread, severity and tremendous negative effects on public health and society (Yildirim & Guler, 2020). Therefore, it is necessary to come up with forecasting and control models for the pandemic. The purpose of this study is to analyze the trends of daily COVID-19 cases in Turkey and consequently make predictions for the future trends. The research is expected to help public health authorities in decision making and policy formulation in order to successfully fight against the COVID-19 pandemic wreaking havoc in the country.

LITERATURE REVIEW

Author/s (Year)	Study Period	Method	Major Findings
Unven & Demirel (2020)	March – May	ARIMA models	Cases will continue rising
Helli <i>et al.</i> (2020)	March – April	Long Short-term Memory Network, ARIMA & Holt-Winters models	Holt-Winters approach will dampened trend gives superior results. Cases will continue to rise in the country
Aslan <i>et al.</i> (2020)	March – April	ODE model	Cases are forecasted to rise
Arslan <i>et al.</i> (2020)	March – May	SEIR model	Approximately 16 million people can be prevented from being infected and 94000 deaths can be prevented by full compliance with the measures taken
Oztoprak & Javed (2020)	March – April	Linear Regression Analysis	In the initial stages, the outbreak will follow a linear upwards trend
Ozdinc <i>et al.</i> (2020)	March – April	SIR model	The reproduction number for Turkey is 1.4

Source: Literature Review (2020)

METHOD

This paper, in line with Helli *et al.* (2020); applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Turkey. However, the study does not employ other forecasting models also used by Helli *et al.* (2020), for example, the ARIMA and Holt-Winters models; simply because the models usually perform badly in analyzing complex data sets such as COVID-19 case volumes. In rare and special circumstances do these models perform reasonably well when analyzing complex epidemiological data. This article specifically 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 TC series in this study) for all age groups Turkey. The data covers the period 11 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 research paper was gathered from John Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 2: Descriptive statistics

Mean	Median	Minimum	Maximum
1597.3	1443.0	0.00000	5138.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
935.05	0.58539	1.6069	3.2106
5% Perc.	95% Perc.	IQ range	Missing obs.
307.40	4057.2	721.00	0

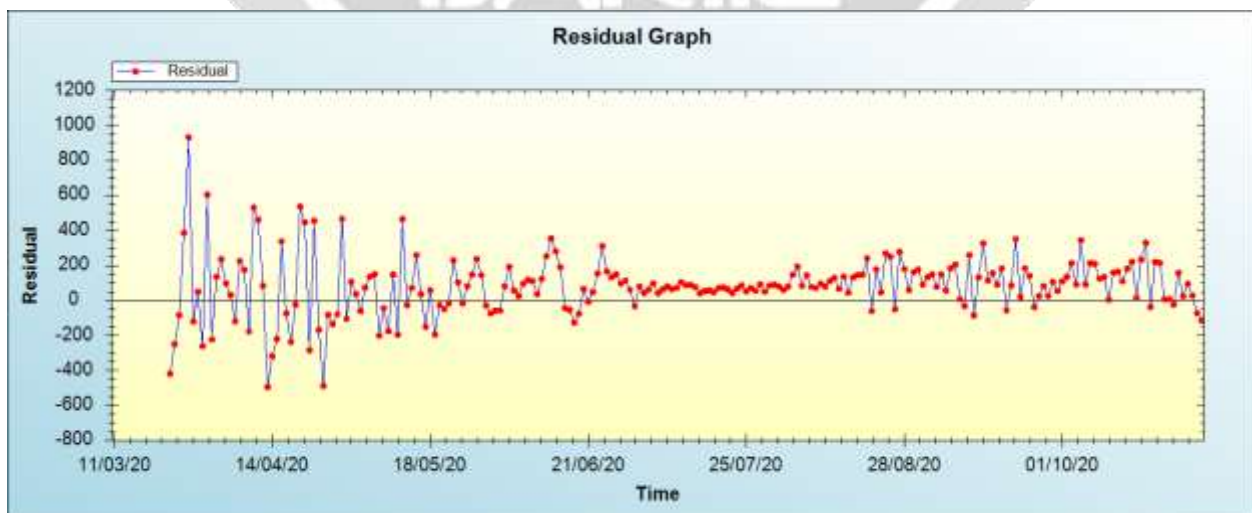
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN TURKEY

Table 3: ANN model summary

Variable	TC
Observations	223 (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	0.066250
MSE	35761.825769
MAE	142.093275

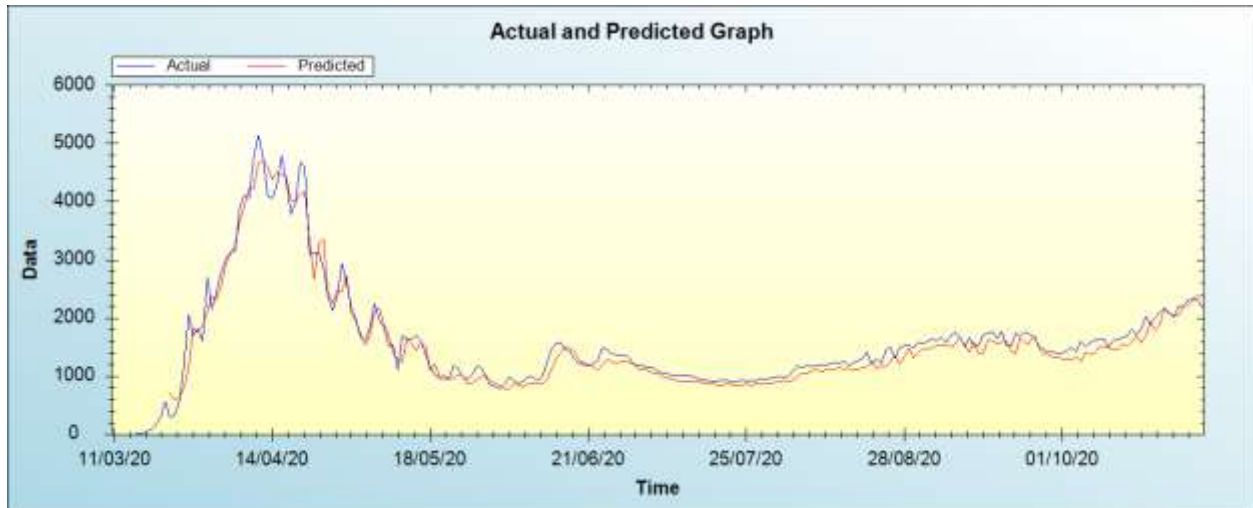
Residual Analysis for the ANN model

Figure 1: Residual analysis



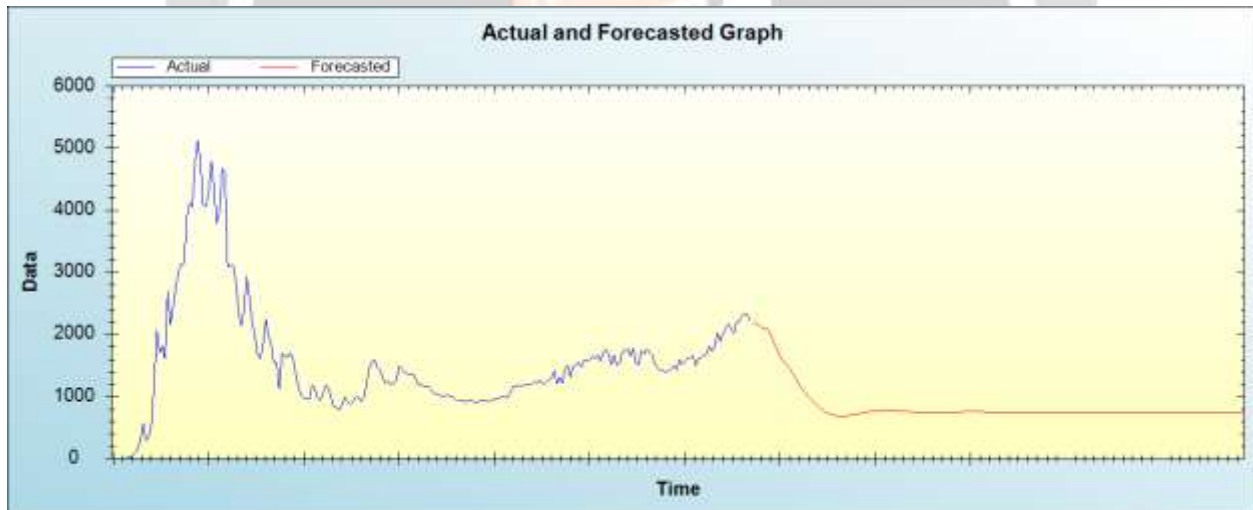
In-sample Forecast for TC

Figure 2: In-sample forecast for the TC series



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

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



Out-of-Sample Forecast for TC: Forecasts only

Table 4: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	2190.2498
02/11/20	2189.0723
03/11/20	2151.7763
04/11/20	2118.2415

05/11/20	2092.9655
06/11/20	2110.2629
07/11/20	2045.2088
08/11/20	1960.8656
09/11/20	1850.3822
10/11/20	1748.5803
11/11/20	1649.7756
12/11/20	1575.1241
13/11/20	1530.9652
14/11/20	1478.9731
15/11/20	1418.7929
16/11/20	1343.5280
17/11/20	1269.1667
18/11/20	1193.6692
19/11/20	1129.5208
20/11/20	1074.5917
21/11/20	1021.3745
22/11/20	969.6376
23/11/20	919.6000
24/11/20	876.2890
25/11/20	835.8923
26/11/20	801.0544
27/11/20	769.8245
28/11/20	744.1549
29/11/20	723.8464
30/11/20	708.5199

01/12/20	697.6942
02/12/20	690.0772
03/12/20	686.6327
04/12/20	686.1931
05/12/20	688.9494
06/12/20	693.5514
07/12/20	700.0296
08/12/20	707.8448
09/12/20	716.5359
10/12/20	725.6396
11/12/20	734.4387
12/12/20	742.9799
13/12/20	750.7576
14/12/20	757.7900
15/12/20	763.6114
16/12/20	768.2671
17/12/20	771.6999
18/12/20	773.9543
19/12/20	775.1018
20/12/20	775.1386
21/12/20	774.3236
22/12/20	772.7446
23/12/20	770.6607
24/12/20	768.1426
25/12/20	765.3937
26/12/20	762.5495

27/12/20	759.7531
28/12/20	757.1186
29/12/20	754.6956
30/12/20	752.5813
31/12/20	750.7933
01/01/21	749.3863
02/01/21	748.3349
03/01/21	747.6413
04/01/21	747.2762
05/01/21	747.2121
06/01/21	747.4125
07/01/21	747.8213
08/01/21	748.4011
09/01/21	749.0967
10/01/21	749.8738
11/01/21	750.6815
12/01/21	751.4865
13/01/21	752.2540
14/01/21	752.9599
15/01/21	753.5856
16/01/21	754.1139
17/01/21	754.5395
18/01/21	754.8569
19/01/21	755.0717
20/01/21	755.1871
21/01/21	755.2138

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22/01/21	755.1621
23/01/21	755.0458
24/01/21	754.8793
25/01/21	754.6754
26/01/21	754.4486
27/01/21	754.2104
28/01/21	753.9730
29/01/21	753.7454
30/01/21	753.5357
31/01/21	753.3496
01/02/21	753.1913
02/02/21	753.0636
03/02/21	752.9670
04/02/21	752.9012
05/02/21	752.8643
06/02/21	752.8540
07/02/21	752.8666
08/02/21	752.8987
09/02/21	752.9460
10/02/21	753.0044
11/02/21	753.0702
12/02/21	753.1395
13/02/21	753.2091
14/02/21	753.2760
15/02/21	753.3380
16/02/21	753.3933

17/02/21	753.4405
18/02/21	753.4788
19/02/21	753.5081
20/02/21	753.5283
21/02/21	753.5399
22/02/21	753.5437
23/02/21	753.5407
24/02/21	753.5318
25/02/21	753.5184
26/02/21	753.5015
27/02/21	753.4824
28/02/21	753.4622
01/03/21	753.4418
02/03/21	753.4221
03/03/21	753.4037
04/03/21	753.3873
05/03/21	753.3732
06/03/21	753.3617
07/03/21	753.3529
08/03/21	753.3467
09/03/21	753.3430
10/03/21	753.3417
11/03/21	753.3424
12/03/21	753.3448
13/03/21	753.3486
14/03/21	753.3534

15/03/21	753.3590
16/03/21	753.3649
17/03/21	753.3709
18/03/21	753.3767
19/03/21	753.3821
20/03/21	753.3870
21/03/21	753.3912
22/03/21	753.3946
23/03/21	753.3973
24/03/21	753.3992
25/03/21	753.4003
26/03/21	753.4008
27/03/21	753.4006
28/03/21	753.4000
29/03/21	753.3989
30/03/21	753.3975
31/03/21	753.3959
01/04/21	753.3942
02/04/21	753.3924
03/04/21	753.3907
04/04/21	753.3891
05/04/21	753.3877
06/04/21	753.3864
07/04/21	753.3854
08/04/21	753.3846
09/04/21	753.3840

10/04/21	753.3837
11/04/21	753.3835
12/04/21	753.3835
13/04/21	753.3837
14/04/21	753.3840
15/04/21	753.3844
16/04/21	753.3849
17/04/21	753.3854
18/04/21	753.3859
19/04/21	753.3864
20/04/21	753.3869
21/04/21	753.3873
22/04/21	753.3877
23/04/21	753.3880
24/04/21	753.3882
25/04/21	753.3884
26/04/21	753.3885
27/04/21	753.3886
28/04/21	753.3886
29/04/21	753.3885
30/04/21	753.3884

Over the period under study, the maximum number of daily cases has been 5138 cases while the average has been shown to be 1597 cases per day as indicated in table 2 above. Table 3 shows the summary of the applied model and its residual diagnostics are shown in figure. Figure confirms that the model is stable and acceptable. Figure 2 shows the in-sample predictions while figure 3 and table display out-of-sample predictions. From table 4, we can see that daily COVID-19 cases in Turkey are forecasted to decline from the estimated 2190 cases on November 1, 2020 to an equilibrium level of 753 cases per day somewhere around March 1, 2021. Generally, our model suggests that daily COVID-19 cases in Turkey are declining although the pandemic is clearly far from ending in the country. The results of the study are not really surprising but rather

in line with previous studies such as Unvan & Demirel (2020), Helli *et al.* (2020), Aslan *et al.* (2020), as well as Oztoprak & Javed (2020).

CONCLUSION & RECOMMENDATIONS

COVID-19, declared as a pandemic by WHO, is currently the most feared disease in the world, affecting everyone in this world, in one way or the other; directly or indirectly. Turkey, has not been spared by this deadly virus. Indeed, COVID-19 has become a serious threat in the country. It has become critical to forecast the daily new COVID-19 cases in Turkey: this information is important for policy makers to be in a position to control the pandemic, particularly within the next 6 months. The study made use of a simple ANN (12, 12, 1) model, based on 235 observations of daily new COVID-19 cases. We strongly recommend that the government of Turkey should continue to ensure strict adherence to lock-down measures while creating awareness about the COVID-19 pandemic. We also urge everyone in the country to be more responsible, especially with regards to social distancing, washing of hands and wearing of masks.

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