

PREDICTION OF DAILY COVID-19 CASES IN THE STATE OF ISRAEL USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In this research article, the ANN approach was applied to analyze daily new COVID-19 cases in Israel. The employed data covers the period 21 February 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 the state of Israel. The results of the study indicate that the COVID-19 epidemic is projected to be under control in the out-of sample period with daily new cases from November 12, 2020 to April 30, 2021 expected to be close to zero ranging between 0-32 cases. The state of Israel should continue on this commendable path by continuously enforcing social distancing measures, wearing masks, hygiene practices and other WHO recommended guidelines on prevention and control of COVID-19.

Keywords: - ANN, COVID-19, Forecasting

INTRODUCTION

In late Dec 2019 the world was attacked by the deadly COVID-19 virus which was discovered in Wuhan, China. (Wang et al, 2020; Wang et al, 2020; Wang et al, 2020; Tang et al, 2020; Read et al, 2020; CDC, 2020). The scientists discovered that the virus was the novel coronavirus SARS-CoV-2. This virus rapidly spread across borders to all the parts of the globe killing millions of people. The most affected people are the minority ethnic groups. COVID-19 was markedly higher for black Americans (61,6 deaths per 100,000) compared to all other ethnic groups in America. (APM Labs, 2020; Hooper et al, 2020). In the United Kingdom mortality was higher in the most deprived compared to the less deprived areas (Off. Natl. Stat, 2020). The government implemented its containment measures on 13 March 2020. All educational facilities were closed, there was emphasis on hygiene, wearing of face masks, social distancing and minimum interaction (Zamir et al, 2020). Israel reported 23,345 confirmed cases and 308 deaths between 21 February 2020 and 25 June 2020 (Saban et al, 2020). The clinical manifestations of COVID-19 include fever, headache, sore throat, chest pains and shortness of breath. (Huang et al, 2020; Li et al, 2020). Elderly people and patients with pre-existing medical conditions tend to develop severe disease (Caramelo et al, 2020). In the state of Israel the Arab population is generally younger than the Jewish population with 4% aged over 65 compared with 15% in the overall Jewish population (Malach & Cahaner, 2020). 45% of mortality from COVID-19 virus in Israel

was reported in nursing homes (Herrera & Zalakain, 2020). There are few empirical studies in Israel which focus on modeling and forecasting COVID-19 cases. One such example was carried out by Getz et al, 2020. The researchers did characterization of Israeli COVID-19 outbreak drivers and forecasting using a versatile web application (NMB-DASA). The study concluded that projections beyond the relaxation phase indicate 85% drop in social relaxation rates needed just to stabilize the current incidence rate and that at least 95% drop is needed to quell the outbreak. In this paper the researchers chose to apply a machine learning algorithm, the artificial neural network (Multilayer Perceptron with a single hidden layer). The findings of this piece of work will uncover the dynamics of the COVID-19 epidemic in Israel as well as stimulating an appropriate evidenced-based approach to the deadly virus.

METHOD

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 state of Israel. This piece of work 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 (referred to as S series in this study) for all age groups in the state of Israel. The data covers the period 21 February 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
1237.9	576.00	0.00000	11316.
Std. Dev.	C.V.	Skewness	Ex. Kurtosis
1709.5	1.3810	2.5421	8.2848
5% Perc.	95% Perc.	IQ range	Missing obs.
3.0000	4728.8	1611.0	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN ISRAEL

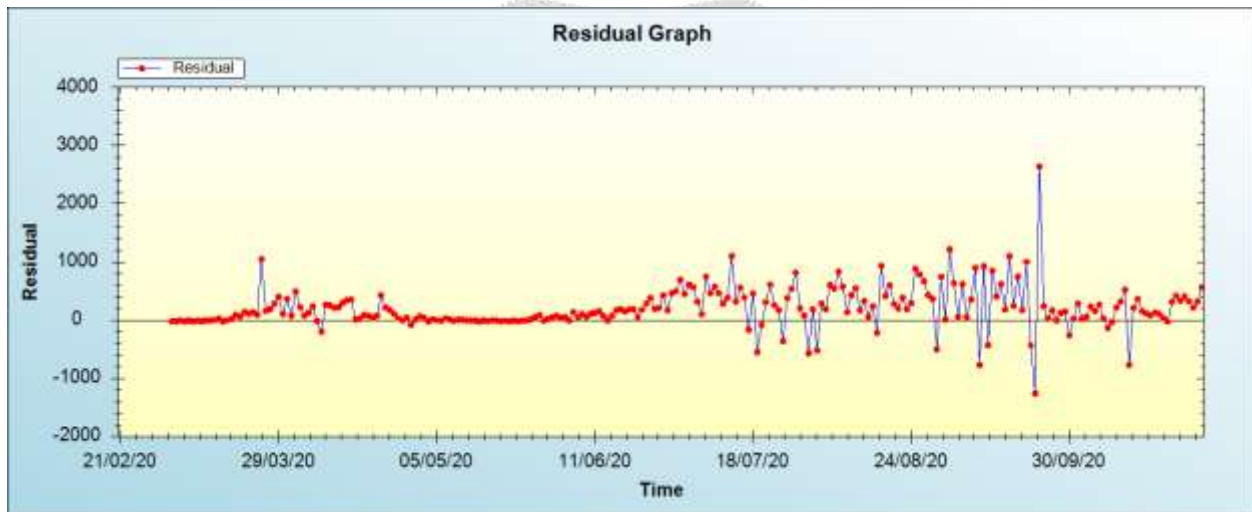
Table 2: ANN model summary

Variable	S
Observations	242 (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	0.064612
MSE	164992.365930
MAE	266.872205

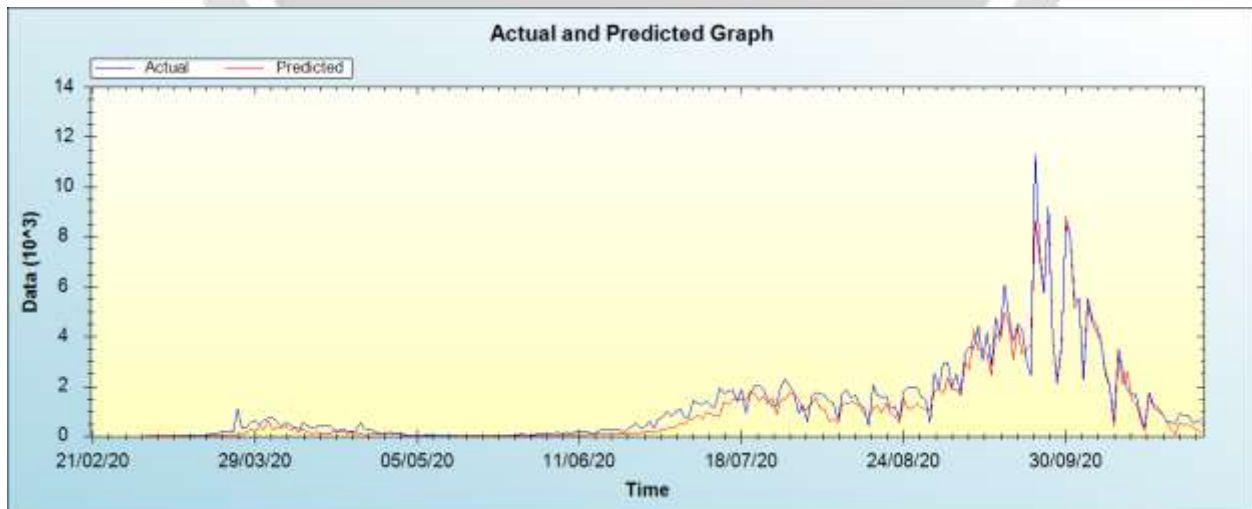
Residual Analysis for the ANN model

Figure 1: Residual analysis



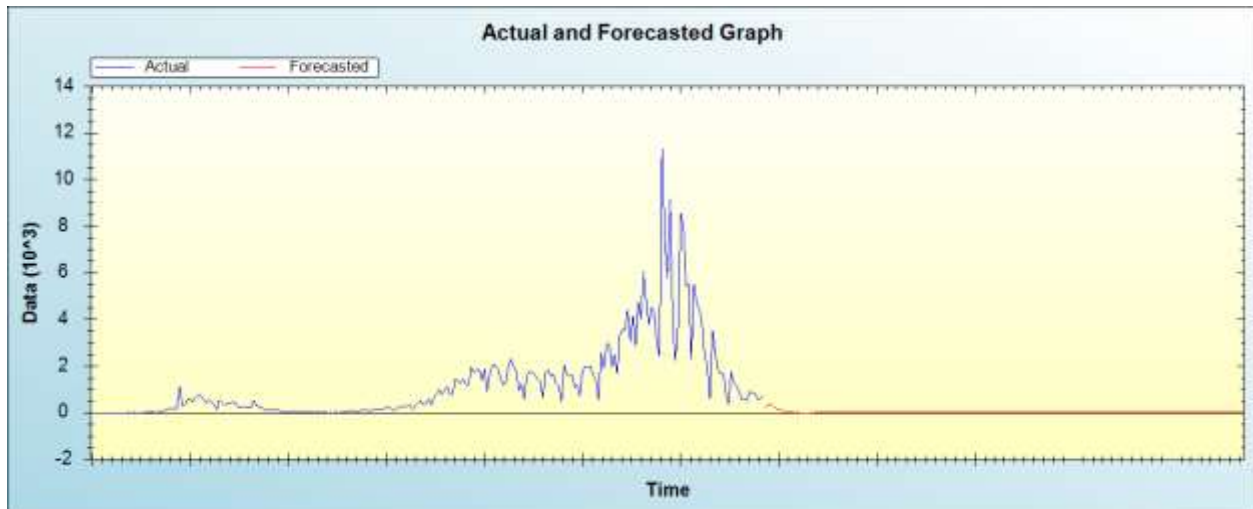
In-sample Forecast for S

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: Predictions

Day/Month/year	Forecasted daily new COVID-19 cases
01/11/20	214.7305
02/11/20	365.9821
03/11/20	381.5391
04/11/20	280.3613
05/11/20	177.5189
06/11/20	157.9390
07/11/20	132.6836
08/11/20	38.3688
09/11/20	47.0509
10/11/20	45.3384
11/11/20	48.1819
12/11/20	5.6313
13/11/20	17.8130
14/11/20	8.3999
15/11/20	-6.8026

16/11/20	2.2531
17/11/20	9.6674
18/11/20	16.1724
19/11/20	9.8484
20/11/20	18.8079
21/11/20	17.5176
22/11/20	18.5377
23/11/20	21.3213
24/11/20	27.4510
25/11/20	29.5388
26/11/20	28.9622
27/11/20	32.1518
28/11/20	31.4238
29/11/20	32.0311
30/11/20	32.2572
01/12/20	34.2579
02/12/20	34.0920
03/12/20	33.8958
04/12/20	34.1471
05/12/20	33.6524
06/12/20	33.3894
07/12/20	33.1224
08/12/20	33.5515
09/12/20	33.1582
10/12/20	33.0452
11/12/20	32.8625

12/12/20	32.6725
13/12/20	32.4509
14/12/20	32.3612
15/12/20	32.4521
16/12/20	32.3241
17/12/20	32.3121
18/12/20	32.2441
19/12/20	32.2266
20/12/20	32.1549
21/12/20	32.1745
22/12/20	32.2121
23/12/20	32.2074
24/12/20	32.2225
25/12/20	32.2200
26/12/20	32.2328
27/12/20	32.2190
28/12/20	32.2423
29/12/20	32.2572
30/12/20	32.2677
31/12/20	32.2737
01/01/21	32.2782
02/01/21	32.2821
03/01/21	32.2786
04/01/21	32.2863
05/01/21	32.2892
06/01/21	32.2928

A large, semi-transparent watermark of the IJARIE logo is centered over the table. The logo features a stylized globe with a swoosh and the acronym 'IJARIE' below it.

07/01/21	32.2922
08/01/21	32.2933
09/01/21	32.2920
10/01/21	32.2900
11/01/21	32.2909
12/01/21	32.2907
13/01/21	32.2910
14/01/21	32.2899
15/01/21	32.2898
16/01/21	32.2885
17/01/21	32.2878
18/01/21	32.2875
19/01/21	32.2874
20/01/21	32.2874
21/01/21	32.2870
22/01/21	32.2870
23/01/21	32.2866
24/01/21	32.2865
25/01/21	32.2864
26/01/21	32.2865
27/01/21	32.2865
28/01/21	32.2865
29/01/21	32.2866
30/01/21	32.2865
31/01/21	32.2865
01/02/21	32.2866

02/02/21	32.2867
03/02/21	32.2867
04/02/21	32.2867
05/02/21	32.2867
06/02/21	32.2867
07/02/21	32.2868
08/02/21	32.2868
09/02/21	32.2868
10/02/21	32.2868
11/02/21	32.2868
12/02/21	32.2868
13/02/21	32.2868
14/02/21	32.2868
15/02/21	32.2868
16/02/21	32.2868
17/02/21	32.2868
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22/02/21	32.2868
23/02/21	32.2868
24/02/21	32.2868
25/02/21	32.2868
26/02/21	32.2868
27/02/21	32.2868

A large, semi-transparent watermark of the IJARIE logo is centered over the table. The logo features a stylized globe with a swoosh and the acronym 'IJARIE' below it.

28/02/21	32.2868
01/03/21	32.2868
02/03/21	32.2868
03/03/21	32.2868
04/03/21	32.2868
05/03/21	32.2868
06/03/21	32.2868
07/03/21	32.2868
08/03/21	32.2868
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22/03/21	32.2868
23/03/21	32.2868
24/03/21	32.2868
25/03/21	32.2868

A large, semi-transparent watermark of the IJARIE logo is centered over the table. The logo features a stylized globe with a swoosh and the acronym 'IJARIE' below it.

26/03/21	32.2868
27/03/21	32.2868
28/03/21	32.2868
29/03/21	32.2868
30/03/21	32.2868
31/03/21	32.2868
01/04/21	32.2868
02/04/21	32.2868
03/04/21	32.2868
04/04/21	32.2868
05/04/21	32.2868
06/04/21	32.2868
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24/04/21	32.2868
25/04/21	32.2868
26/04/21	32.2868
27/04/21	32.2868
28/04/21	32.2868
29/04/21	32.2868
30/04/21	32.2868

Figure 1 shows that over the study period the daily number of new COVID-19 cases are 0 and 11316. The average daily new coronavirus cases was 1237 cases. The data is positively skewed with a kurtosis of 8 meaning that the given data is not normally distributed. Our model simulates the observed data very well. The residual graph and model evaluation criteria indicate that the model is stable. The out of sample forecasts indicate that the COVID-19 epidemic will be under control with daily new cases of around 0-32 cases from November 12, 2020 to April 30, 2021.

CONCLUSION & RECOMMENDATIONS

The state of Israel is one of the countries in the World which responded promptly to the COVID-19 epidemic by closure of all schools, wearing masks, hygiene practices and social distancing measures. Our study findings revealed that the COVID-19 epidemic will be under control in the out-sample period with daily new cases close to zero, that is ranging from 0-32 cases from 12 November 2020 to 30 April, 2021. Therefore the state of Israel should continue on this desirable path by continuously enforcing social distancing and other WHO recommended guidelines on prevention and control of SARS-CoV-2.

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