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# Forecasting Covid-19 Deaths in the State of Israel

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 deaths in Israel. The employed data covers the period 1 January 2020 to 20 April 2021 and the out-of-sample period ranges over the period21 April to 31 August 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is quite stable. The results of the study indicate that daily COVID-19 mortality cases in Israel are likely to be rare over the out-of-sample period. Therefore there is need for the state of Israel to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and COVID-19 vaccination.**

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

## I. INTRODUCTION

The emergence of the deadly novel coronavirus, SARS-COV2 in Wuhan City, China in December 2019 continues to torment the World as millions of people continue to suffer from the COVID-19 disease and continue to die from its complications. Many countries are channeling their financial and human resources towards COVID-19 response. The first case of COVID-19 in Israel was reported on the 21st of February 2020 (Last, 2020). Following the detection of the first case of SARS-COV2 in Israel, the government adopted the WHO guidelines to prevent and control the epidemic which include social distancing, regular hand washing, wearing face masks, contact tracing, quarantine, isolation and treatment of positive cases (Miller et al, 2020). The second wave of COVID-19 was characterized by high numbers of daily new infections and Israel became the first country worldwide with the highest rate of COVID-19 infections per capita globally (Times of Israel, 2020). The aim of this study is to predict daily COVID-19 deaths in Israel using the artificial neural network approach due to its high predictive accuracy (Maradze et al, 2021; Nyoni et al, 2021; Zhao et al, 2020; Nyoni et al, 2020). The study results are envisioned to assist in the evaluation of COVID-19 mitigation measures and to prepare adequate resources to fight the epidemic.

## II. LITERATURE REVIEW

Hakla (2021) investigated excess mortality during the COVID-19 pandemic in Israel. Mortality rates between March to November 2020 for various demographic groups, cities, month and week were compared with the average rate during 2017–2019 for the same groups or periods. The authors concluded that Israel has seen significant excess mortality in August–October 2020, particularly in the Arab sector. The excess mortality in March–November was statistically significant only at older ages, over 65. A similar study was also done by Rossman et al (2021). They studied the ramifications of hospital load due to COVID-19 morbidity on in-hospital mortality of patients with COVID-19 by analyzing records of all 22,636 COVID-19 patients hospitalized in Israel from mid-July 2020 to mid-January 2021.The study revealed that in-hospital mortality rate of patients with COVID-19 significantly increased during periods of moderate –high patient load when compared to periods of lower patient load. The NMB-DASA web app was applied by Getz et al (2020) to forecast COVID-19 cases in Israel. The study concluded that projections beyond the relaxation phase indicate that an 85% drop in social relaxation rates were needed just to stabilize the current incidence rate and that at least a 95% drop was needed to quell the outbreak. The artificial neural network model was applied by Nyoni et al (2020) to predict daily COVID-19 cases in Israel using daily data from John Hopkins University database. The model predictions suggested that daily COVID-19 cases would be close to zero in the out of sample period.

## III. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent

 

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activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting COVID-19 mortality cases Israel.

### Data Issues

This study is based on daily COVID-19 mortality cases in Israel for the period 1 January 2020 – 20 April 2021. The out-of-sample forecast covers the period 21 April – 31 August 2021. All the data employed in this research paper was gathered from the Johns Hopkins University (USA).

## IV. FINDINGS OF THE STUDY

### ANN Model Summary

**Table 1: ANN model summary**

| | |
|---|---|
| Variable | IS |
| Observations | 464 (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 | 0.114203 |
| MSE | 44.380107 |
| MAE | 4.708626 |

*Residual Analysis for the Applied Model*

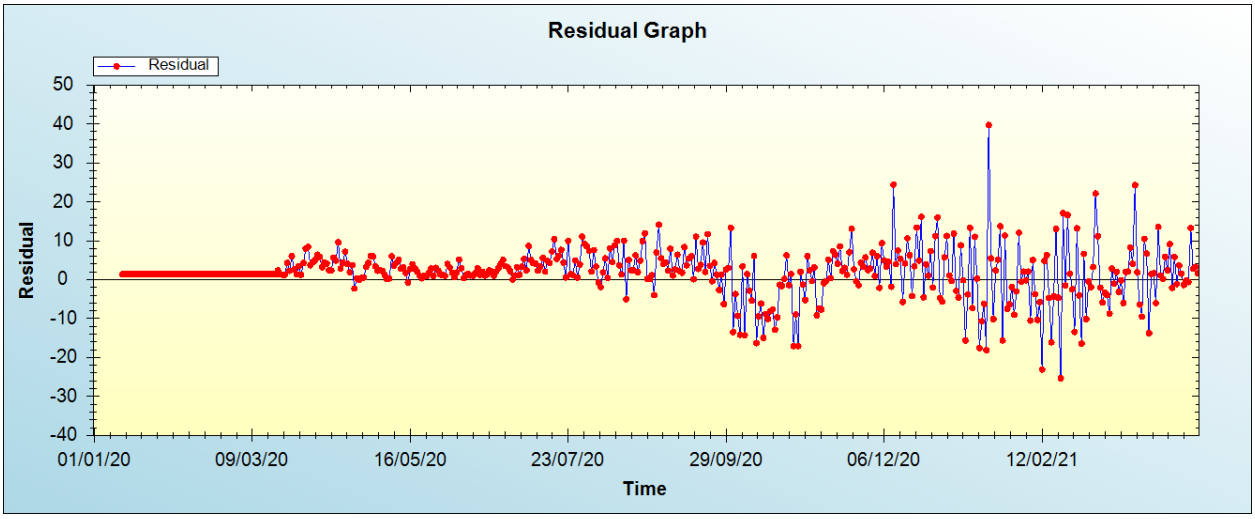


**Figure 1: Residual analysis**

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*In-sample Forecast for IS*

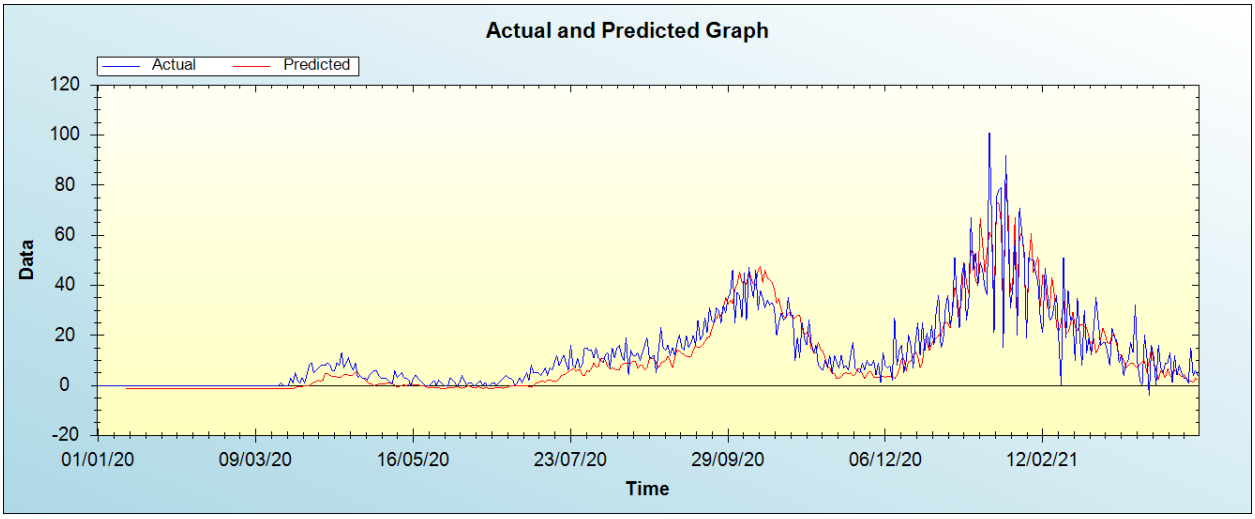


**Figure 2: In-sample forecast for the IS series**

*Out-of-Sample Forecast for IS: Actual and Forecasted Graph*

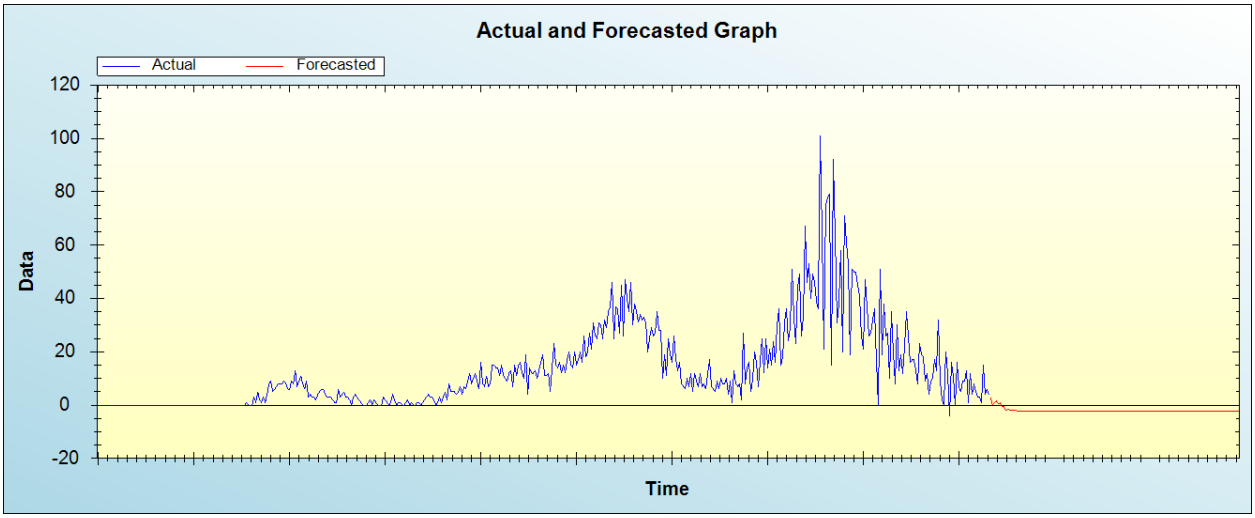


**Figure 3: Out-of-sample forecast for IS: actual and forecasted graph**

*Out-of-Sample Forecast for IS: Forecasts only*

**Table 2: Tabulated out-of-sample forecasts**

| Date | Forecasts |
|---|---|
| 21/04/21 | 2.6574 |
| 22/04/21 | 0.0104 |
| 23/04/21 | 0.9013 |
| 24/04/21 | 1.5643 |
| 25/04/21 | 0.5226 |
| 26/04/21 | 0.8654 |
| 27/04/21 | -0.4296 |
| 28/04/21 | -0.4455 |
| 29/04/21 | -1.8838 |
| 30/04/21 | -1.6281 |
| 01/05/21 | -1.7658 |
| 02/05/21 | -1.8246 |
| 03/05/21 | -1.9090 |
| 04/05/21 | -1.9869 |
| 05/05/21 | -2.0860 |

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| | |
|---|---|
| 06/05/21 | -2.2966 |
| 07/05/21 | -2.2840 |
| 08/05/21 | -2.3007 |
| 09/05/21 | -2.2716 |
| 10/05/21 | -2.2739 |
| 11/05/21 | -2.2313 |
| 12/05/21 | -2.2515 |
| 13/05/21 | -2.2635 |
| 14/05/21 | -2.2595 |
| 15/05/21 | -2.2488 |
| 16/05/21 | -2.2406 |
| 17/05/21 | -2.2290 |
| 18/05/21 | -2.2148 |
| 19/05/21 | -2.2135 |
| 20/05/21 | -2.2135 |
| 21/05/21 | -2.2119 |
| 22/05/21 | -2.2097 |
| 23/05/21 | -2.2092 |
| 24/05/21 | -2.2061 |
| 25/05/21 | -2.2036 |
| 26/05/21 | -2.2033 |
| 27/05/21 | -2.2039 |
| 28/05/21 | -2.2040 |
| 29/05/21 | -2.2043 |
| 30/05/21 | -2.2048 |
| 31/05/21 | -2.2046 |
| 01/06/21 | -2.2044 |
| 02/06/21 | -2.2046 |
| 03/06/21 | -2.2048 |
| 04/06/21 | -2.2050 |
| 05/06/21 | -2.2052 |
| 06/06/21 | -2.2055 |
| 07/06/21 | -2.2055 |
| 08/06/21 | -2.2055 |
| 09/06/21 | -2.2055 |
| 10/06/21 | -2.2056 |
| 11/06/21 | -2.2056 |
| 12/06/21 | -2.2056 |
| 13/06/21 | -2.2057 |
| 14/06/21 | -2.2057 |
| 15/06/21 | -2.2057 |
| 16/06/21 | -2.2057 |
| 17/06/21 | -2.2057 |
| 18/06/21 | -2.2057 |
| 19/06/21 | -2.2057 |
| 20/06/21 | -2.2057 |
| 21/06/21 | -2.2057 |
| 22/06/21 | -2.2056 |
| 23/06/21 | -2.2056 |
| 24/06/21 | -2.2056 |
| 25/06/21 | -2.2056 |
| 26/06/21 | -2.2056 |
| 27/06/21 | -2.2056 |
| 28/06/21 | -2.2056 |
| 29/06/21 | -2.2056 |
| 30/06/21 | -2.2056 |
| 01/07/21 | -2.2056 |
| 02/07/21 | -2.2056 |
| 03/07/21 | -2.2056 |
| 04/07/21 | -2.2056 |
| 05/07/21 | -2.2056 |
| 06/07/21 | -2.2056 |
| 07/07/21 | -2.2056 |
| 08/07/21 | -2.2056 |

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| | |
|---|---|
| 09/07/21 | -2.2056 |
| 10/07/21 | -2.2056 |
| 11/07/21 | -2.2056 |
| 12/07/21 | -2.2056 |
| 13/07/21 | -2.2056 |
| 14/07/21 | -2.2056 |
| 15/07/21 | -2.2056 |
| 16/07/21 | -2.2056 |
| 17/07/21 | -2.2056 |
| 18/07/21 | -2.2056 |
| 19/07/21 | -2.2056 |
| 20/07/21 | -2.2056 |
| 21/07/21 | -2.2056 |
| 22/07/21 | -2.2056 |
| 23/07/21 | -2.2056 |
| 24/07/21 | -2.2056 |
| 25/07/21 | -2.2056 |
| 26/07/21 | -2.2056 |
| 27/07/21 | -2.2056 |
| 28/07/21 | -2.2056 |
| 29/07/21 | -2.2056 |
| 30/07/21 | -2.2056 |
| 31/07/21 | -2.2056 |
| 01/08/21 | -2.2056 |
| 02/08/21 | -2.2056 |
| 03/08/21 | -2.2056 |
| 04/08/21 | -2.2056 |
| 05/08/21 | -2.2056 |
| 06/08/21 | -2.2056 |
| 07/08/21 | -2.2056 |
| 08/08/21 | -2.2056 |
| 09/08/21 | -2.2056 |
| 10/08/21 | -2.2056 |
| 11/08/21 | -2.2056 |
| 12/08/21 | -2.2056 |
| 13/08/21 | -2.2056 |
| 14/08/21 | -2.2056 |
| 15/08/21 | -2.2056 |
| 16/08/21 | -2.2056 |
| 17/08/21 | -2.2056 |
| 18/08/21 | -2.2056 |
| 19/08/21 | -2.2056 |
| 20/08/21 | -2.2056 |
| 21/08/21 | -2.2056 |
| 22/08/21 | -2.2056 |
| 23/08/21 | -2.2056 |
| 24/08/21 | -2.2056 |
| 25/08/21 | -2.2056 |
| 26/08/21 | -2.2056 |
| 27/08/21 | -2.2056 |
| 28/08/21 | -2.2056 |
| 29/08/21 | -2.2056 |
| 30/08/21 | -2.2056 |
| 31/08/21 | -2.2056 |

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that daily COVID-19 mortality cases in Israel are likely to be rare over the out-of-sample period.

## V. CONCLUSION AND POLICY RECOMMENDATIONS

Public health surveillance is an essential tool for public health programming. It facilitates planning and allocation of resources. In this COVID-19 pandemic predictive modeling becomes one of the key tools for early detection of localized or

 

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generalized outbreaks. It provides an insight of the likely future trends of confirmed cases and mortalities. In this study the artificial intelligent technique is applied to predict COVID-19 mortality in the state of Israel. The results of the study suggest that daily COVID-19 mortality cases in Israel are likely to be rare over the out-of-sample period. Therefore the authorities in Israel are encouraged to continue COVID-19 vaccination and other recommended WHO guidelines.

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