

Modelling and Forecasting Covid-19 Mortalities in the United States of America Using Artificial Neural Networks (ANN)

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Abstract - In this research paper, the ANN approach was employed to analyze COVID-19 deaths in the United States of America (USA). The employed data covers the period January – December 2020 and the out-of-sample period ranges over the period January – May 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 COVID-19 deaths in the USA will continue to decline significantly in the out-of-sample period. Amongst other policy prescriptions, we strongly advise the US government to continue ensuring strict adherence to COVID-19 guidelines.

Keywords: Modelling, Artificial Neural Networks, ANN.

I. INTRODUCTION

COVID-19, now a public health started in Wuhan, China in December 2019 and has since spread across the globe, Ippolito et al (2020). According to the World Health Organization, as of June 2020, there have been more than 6.4 million confirmed cases and over 380 thousand deaths worldwide. In the US, COVID-19 entered and spread to all 51 states. Mathematical models have been helping inform authorities know the prevalence of the virus and its probability of moving between states and from susceptible to infected people,(WHO, 2020). Despite the US having one of the best healthcare systems, it was hard hit by COVID-19, with it having 29.6 million cases and over 530 000 deaths to date(17/03/2021).

Recent studies show that COVID-19 alone may not kill a person but the underlying conditions may help increase the risk of one dying from COVID-19. Examples of preexisting conditions include respiratory diseases, cancer, infectious diseases, obesity and substance abuse. In addition, these conditions may also include demographic areas and socio-economic conditions. Brown and Jha (2020) conducted a study on mortality in 6 states of USA, they used the Global COVID-19 Assessment of mortality and found that deaths in the USA would be substantial even in the best-case scenario. Coyle et al, (2020) used the National Vital Statistics System (NVSS) to determine race, age and ethnicity of those who died from COVID-19 in the USA. Results were that persons aged above 65 years and members of minority age groups were disproportionately represented among COVID-19 associated deaths. Mollalo et al (2020), used machine learning logarithms to predict the Covid-19 prevalence in the USA.

Results showed that showed that the age-adjusted mortality rates of heart disease; pancreatic cancer; and leukemia, together with two socioeconomic and environmental factors (median household income and total precipitation), are amongst the most significant factors for predicting COVID-19 incidence rates. Murray (2020), predicted health service utilization and deaths due to Covid-19 for each state in the USA, results showed that there was excess demand for hospital services thus ICUs, ventilators and beds, also deaths were seen to increase exponentially. John PA (2019) used the sero prevalence data to estimate infection fatality of coronavirus disease across 51 states of the USA, because of different locations, the infection fatality rate varied substantially.

In this paper we will use the ANN networks to predict COVID-19 related deaths in the USA. ANN models produce reliable estimates and reliable estimates of COVID-19 mortality are crucial to aid control policies and to evaluate the effectiveness of interventions. Results from the forecast may inform public health messaging and mitigation efforts focused on prevention and early detection of infection among disproportionately affected groups so as to minimize subsequent mortality in USA.

II. METHODOLOGY

The study applies the Artificial Neural Network (ANN) approach which is usually celebrated for its capability to learn from any data-set and consequently describe the nonlinear and interaction effects with great accuracy. Arguably, explicit guidelines exist for the determination of the ANN structure hence the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function.

Data Issues

This study is based on daily deaths of COVID-19 in the United States of America (USA) for the period 1 January – 31 December 2020. The out-of-sample forecast covers the period January 2021 – May 2021. All the data employed in this paper was gathered from the World Bank.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	J
Observations	354 (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	0.129965
MSE	73272.318977
MAE	202.455177

Residual Analysis for the Applied Model

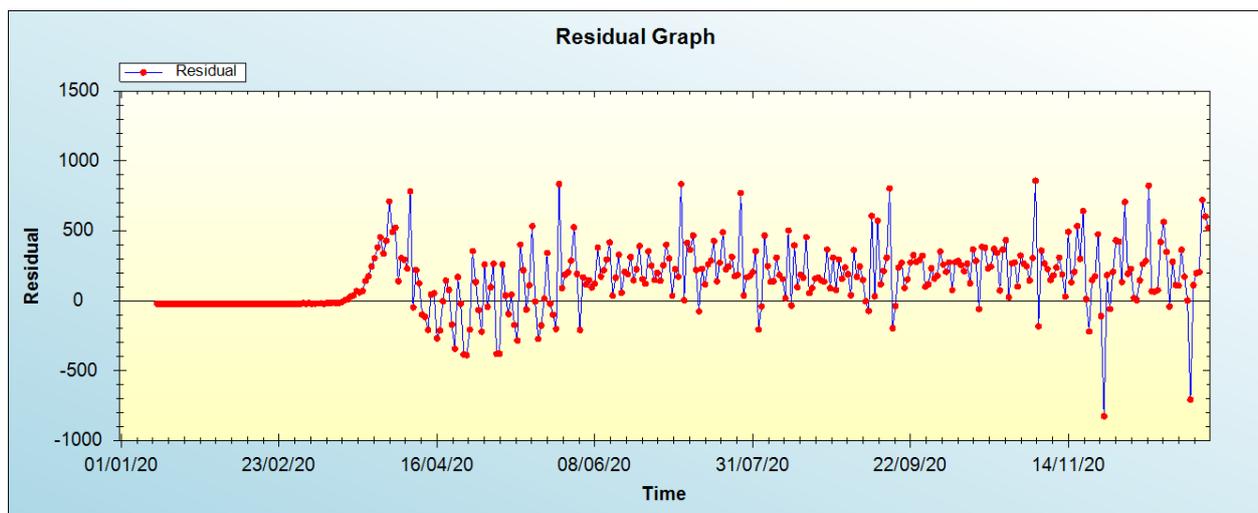


Figure 1: Residual analysis

In-sample Forecast for J

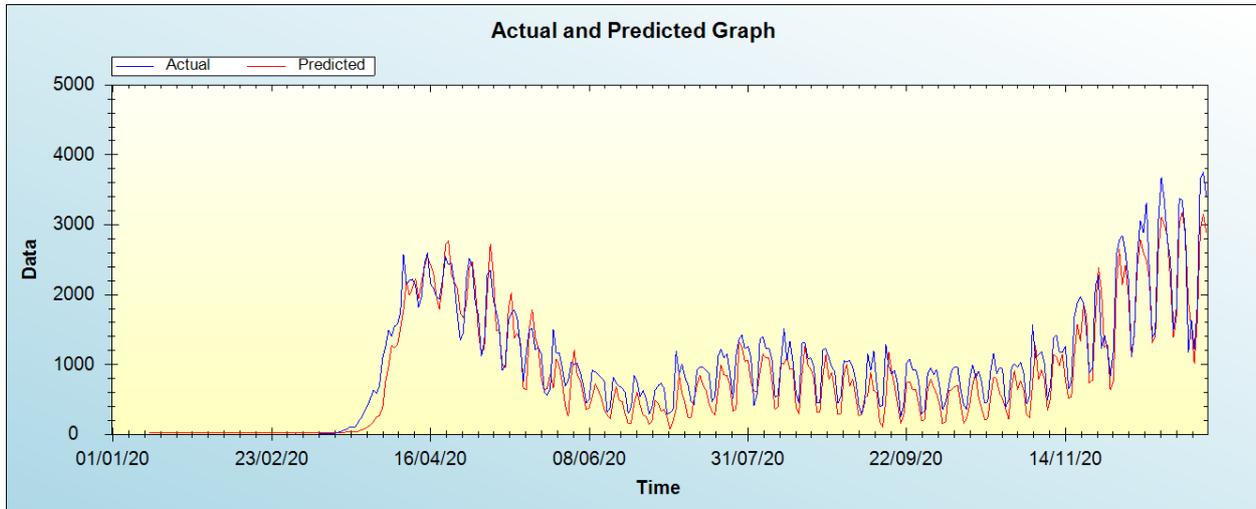


Figure 2: In-sample forecast for the J series

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

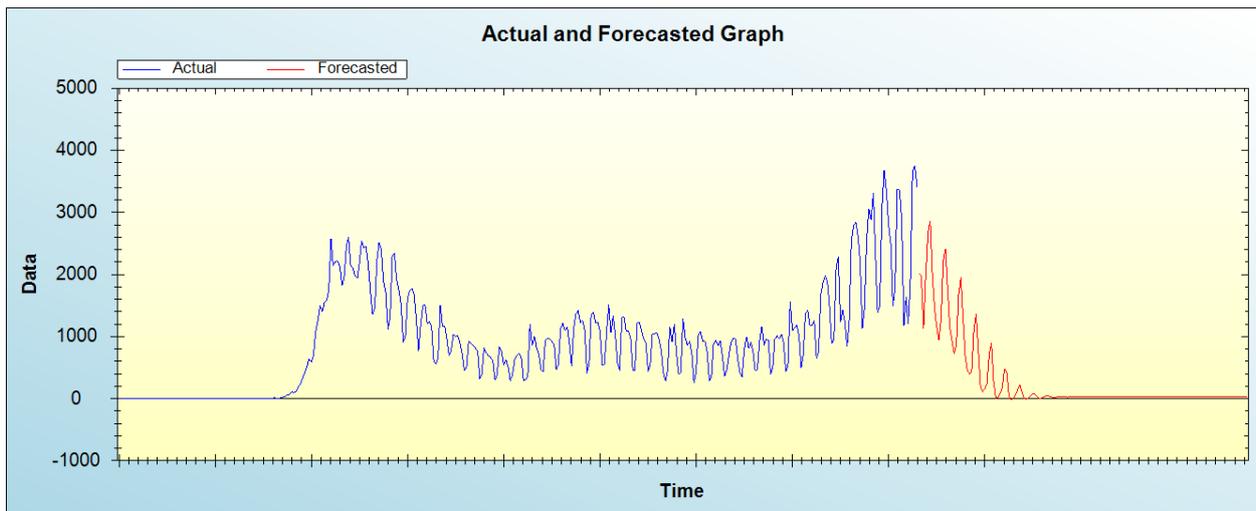


Figure 3: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Date	Forecasts
01/01/21	2021.3404
02/01/21	1971.1045
03/01/21	1133.4056
04/01/21	1954.1975
05/01/21	2656.8010
06/01/21	2865.4994
07/01/21	1997.4037
08/01/21	1463.2024
09/01/21	1162.6049
10/01/21	946.2792
11/01/21	1275.8031
12/01/21	2226.5426

13/01/21	2415.1719
14/01/21	1743.8415
15/01/21	1139.4388
16/01/21	940.5060
17/01/21	728.1711
18/01/21	860.9350
19/01/21	1676.6039
20/01/21	1945.6277
21/01/21	1300.2789
22/01/21	695.8977
23/01/21	454.3916
24/01/21	400.2819
25/01/21	436.4814
26/01/21	1118.8705
27/01/21	1359.6455
28/01/21	765.8472
29/01/21	187.9032
30/01/21	113.2856
31/01/21	157.6094
01/02/21	242.9453
02/02/21	712.6714
03/02/21	890.9990
04/02/21	285.6421
05/02/21	6.6663
06/02/21	23.4911
07/02/21	84.8992
08/02/21	172.1144
09/02/21	479.5099
10/02/21	432.1197
11/02/21	52.3521
12/02/21	-19.4128
13/02/21	11.0917
14/02/21	55.9012
15/02/21	139.2701
16/02/21	220.9812
17/02/21	108.4316
18/02/21	0.4152
19/02/21	-9.0982
20/02/21	17.5803
21/02/21	47.7494
22/02/21	84.4929
23/02/21	71.6388
24/02/21	27.8544
25/02/21	5.1684
26/02/21	10.8097
27/02/21	26.8382
28/02/21	43.0107
01/03/21	46.2060
02/03/21	33.7831
03/03/21	20.7394
04/03/21	18.1326
05/03/21	23.6961
06/03/21	31.4875
07/03/21	35.3172
08/03/21	32.6956
09/03/21	27.1822
10/03/21	24.1347
11/03/21	25.1108

12/03/21	28.2528
13/03/21	30.7080
14/03/21	30.7083
15/03/21	28.7862
16/03/21	26.9820
17/03/21	26.6672
18/03/21	27.6811
19/03/21	28.9108
20/03/21	29.3581
21/03/21	28.8521
22/03/21	28.0272
23/03/21	27.6119
24/03/21	27.8214
25/03/21	28.3338
26/03/21	28.6781
27/03/21	28.6265
28/03/21	28.3171
29/03/21	28.0564
30/03/21	28.0353
31/03/21	28.2092
01/04/21	28.3943
02/04/21	28.4439
03/04/21	28.3529
04/04/21	28.2275
05/04/21	28.1740
06/04/21	28.2160
07/04/21	28.2968
08/04/21	28.3439
09/04/21	28.3290
10/04/21	28.2792
11/04/21	28.2421
12/04/21	28.2433
13/04/21	28.2723
14/04/21	28.2996
15/04/21	28.3043
16/04/21	28.2885
17/04/21	28.2695
18/04/21	28.2630
19/04/21	28.2709
20/04/21	28.2834
21/04/21	28.2897
22/04/21	28.2864
23/04/21	28.2785
24/04/21	28.2733
25/04/21	28.2742
26/04/21	28.2789
27/04/21	28.2829
28/04/21	28.2831
29/04/21	28.2804
30/04/21	28.2776
01/05/21	28.2769
02/05/21	28.2783
03/05/21	28.2802
04/05/21	28.2810
05/05/21	28.2804
06/05/21	28.2791
07/05/21	28.2784
08/05/21	28.2787

09/05/21	28.2794
10/05/21	28.2800
11/05/21	28.2800
12/05/21	28.2795
13/05/21	28.2791
14/05/21	28.2790
15/05/21	28.2793
16/05/21	28.2796
17/05/21	28.2797
18/05/21	28.2795
19/05/21	28.2793
20/05/21	28.2793
21/05/21	28.2793
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23/05/21	28.2795
24/05/21	28.2795
25/05/21	28.2794
26/05/21	28.2794
27/05/21	28.2794
28/05/21	28.2794
29/05/21	28.2794
30/05/21	28.2794
31/05/21	28.2794

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 COVID-19 deaths in the USA will continue to decline significantly in the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

Due to the diversifies nature of the US population, one can see that prevalence of COVID-19 and the date rate were varied especially in areas where there were pre-existing conditions. Using ANN models, the paper managed to predict future COVID-19 deaths during the first wave and the second wave. Recommendations are that there is need for the implementation of community mitigation efforts throughout the nation to help contain virus strains. Relaxation of lockdown restrictions should be done cautiously and the continued use of masks, frequent and washing, and maintenance of social distancing, including avoidance of large gatherings is advised till herd immunity has been achieved.

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