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Forecasting Covid-19 Mortality in Saudi Arabia

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 mortality in Saudi Arabia. This study is based on daily COVID-19 deaths in Saudi Arabia for the period 1 January 2020 – 20 April 2021. The out-of-sample forecast covers the period 21 April – 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 deaths in Saudi Arabia are likely to rise up to an equilibrium case volume of approximately 37 deaths per day over the out-of-sample period. Therefore there is need for the government of Saudi Arabia to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and scaling up COVID-19 vaccination.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The prediction of the evolution of viral infections is a complex task where many real data sets consist of different variables to be employed (Yahya et al, 2021). The COVID-19 pandemic began in Wuhan city of China in December 2019 and spread very fast to many parts of the world (Lai et al, 2020). The pandemic has severely impacted the lives of many people both in developing and developed countries. Therefore prediction of COVID-19 cases and deaths is very crucial as the results will provide an insight of the future trends of cases and mortality, and facilitate planning and allocation of adequate resources for COVID-19 response (Nyoni et al, 2020). Artificial intelligence (AI) has been proven in previous studies that it has high forecasting accuracy and capable to model complex nonlinear data (Yahya et al, 2021). AI is a branch of computer science that uses computer programs (Algorithms) to recognize patterns and analyze data (He et al, 2019; Wang et al, 2019). AI techniques play a big role in decision making in public health and other fields because they can be used in classification, regression, pattern recognition and prediction problems (Steimer et al, 2020). The application of AI will enable strategic decisions to be made in real time in order to minimize the effect of the COVID-19 epidemic (Yahya et al, 2021). Artificial neural networks (ANNs) are widely used AI techniques in the field of medicine. In this study we applied the multilayer perceptron neural network, ANN (12, 12, 1) to predict daily COVID-19 deaths in Saudi Arabia. The findings of this paper are envisioned to shade light on the likely future trends of COVID-19 mortality and facilitate adequate resource mobilization for the COVID-19 response.

II. 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 activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting COVID-19 deaths in Saudi Arabia.

Data Issues

This study is based on daily COVID-19 deaths in Saudi Arabia 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).

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III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	A
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	0.091808
MSE	8.751266
MAE	2.283917

Residual Analysis for the Applied Model

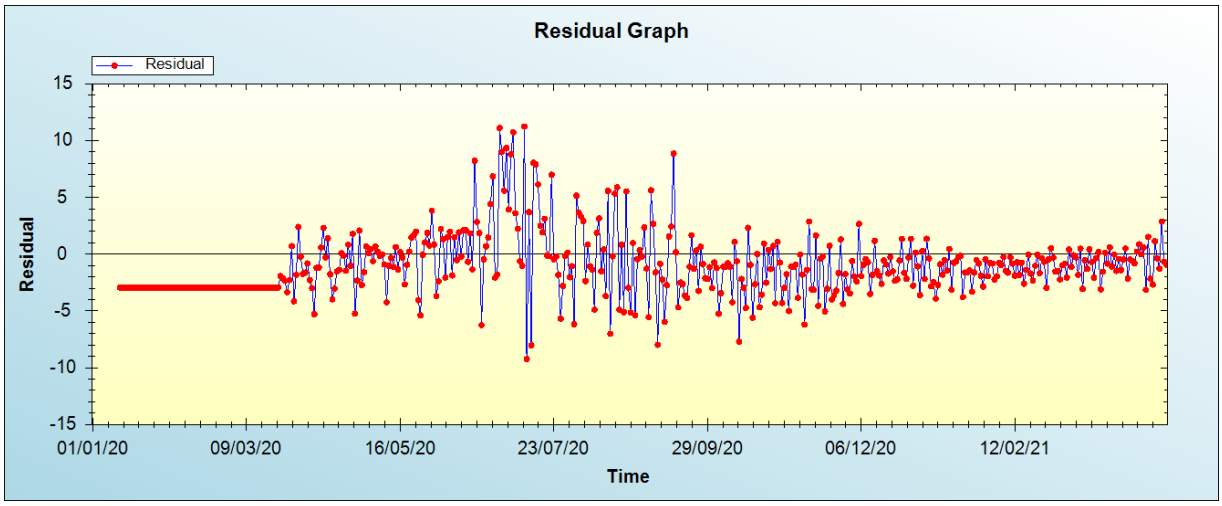

Figure 1: Residual analysis

In-sample Forecast for A

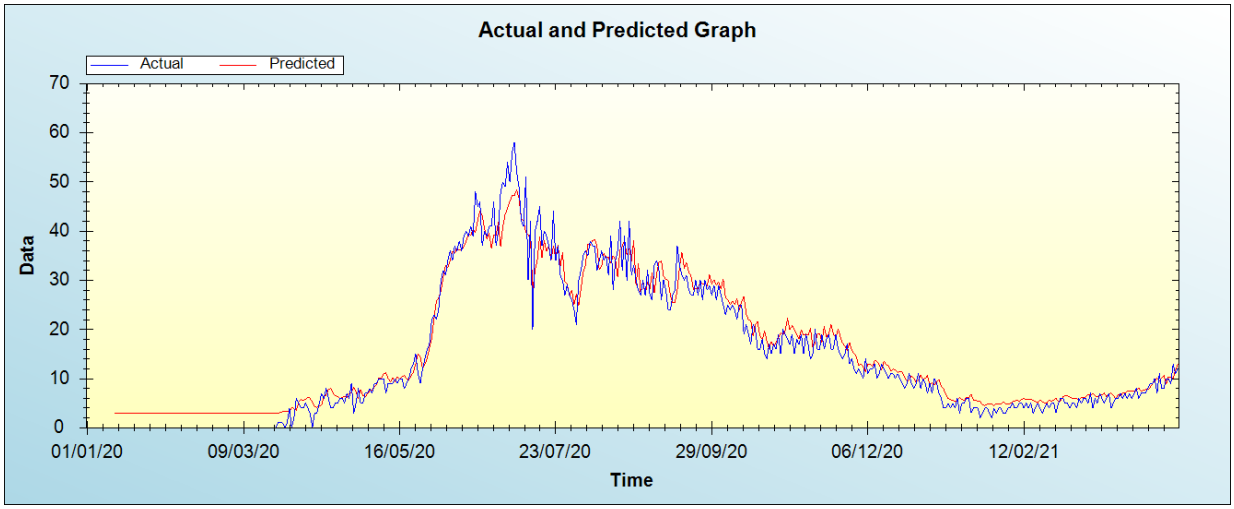

Figure 2: In-sample forecast for the A series

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

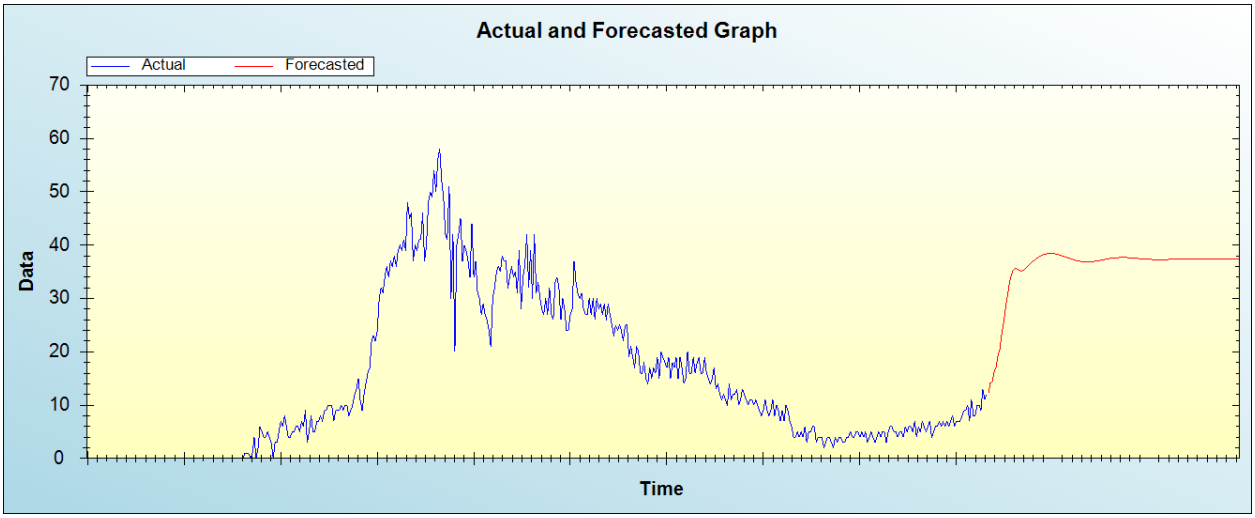

Figure 3: Out-of-sample forecast for A: actual and forecasted graph

Out-of-Sample Forecast for A: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Date	Forecasts
21/04/21	12.2727
22/04/21	14.1737
23/04/21	14.3580
24/04/21	16.2346
25/04/21	17.1198
26/04/21	19.2113
27/04/21	20.5296
28/04/21	23.3668
29/04/21	25.3324
30/04/21	28.2421
01/05/21	30.4188
02/05/21	32.7657
03/05/21	34.2556
04/05/21	35.2276
05/05/21	35.5904
06/05/21	35.5579
07/05/21	35.3114
08/05/21	35.1769
09/05/21	35.1913
10/05/21	35.4611
11/05/21	35.7924
12/05/21	36.2072
13/05/21	36.5196
14/05/21	36.8465
15/05/21	37.1068
16/05/21	37.3876
17/05/21	37.6162
18/05/21	37.8555
19/05/21	38.0294
20/05/21	38.1994
21/05/21	38.3019
22/05/21	38.3964
23/05/21	38.4243
24/05/21	38.4457
25/05/21	38.4125
26/05/21	38.3766
27/05/21	38.2952

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28/05/21	38.2158
29/05/21	38.0992
30/05/21	37.9910
31/05/21	37.8550
01/06/21	37.7340
02/06/21	37.5938
03/06/21	37.4745
04/06/21	37.3442
05/06/21	37.2393
06/06/21	37.1298
07/06/21	37.0490
08/06/21	36.9681
09/06/21	36.9174
10/06/21	36.8694
11/06/21	36.8512
12/06/21	36.8366
13/06/21	36.8498
14/06/21	36.8656
15/06/21	36.9056
16/06/21	36.9462
17/06/21	37.0062
18/06/21	37.0635
19/06/21	37.1352
20/06/21	37.2005
21/06/21	37.2750
22/06/21	37.3398
23/06/21	37.4091
24/06/21	37.4660
25/06/21	37.5238
26/06/21	37.5673
27/06/21	37.6094
28/06/21	37.6365
29/06/21	37.6609
30/06/21	37.6708
01/07/21	37.6778
02/07/21	37.6716
03/07/21	37.6633
04/07/21	37.6436
05/07/21	37.6232
06/07/21	37.5937
07/07/21	37.5652
08/07/21	37.5301
09/07/21	37.4977
10/07/21	37.4611
11/07/21	37.4289
12/07/21	37.3947
13/07/21	37.3661
14/07/21	37.3373
15/07/21	37.3151
16/07/21	37.2938
17/07/21	37.2796
18/07/21	37.2669
19/07/21	37.2613
20/07/21	37.2574
21/07/21	37.2600
22/07/21	37.2640
23/07/21	37.2736
24/07/21	37.2840
25/07/21	37.2988
26/07/21	37.3135
27/07/21	37.3314
28/07/21	37.3483
29/07/21	37.3671
30/07/21	37.3839

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31/07/21	37.4016
01/08/21	37.4165
02/08/21	37.4314
03/08/21	37.4430
04/08/21	37.4540
05/08/21	37.4616
06/08/21	37.4681
07/08/21	37.4712
08/08/21	37.4732
09/08/21	37.4721
10/08/21	37.4701
11/08/21	37.4654
12/08/21	37.4601
13/08/21	37.4527
14/08/21	37.4453
15/08/21	37.4363
16/08/21	37.4278
17/08/21	37.4183
18/08/21	37.4097
19/08/21	37.4008
20/08/21	37.3932
21/08/21	37.3856
22/08/21	37.3796
23/08/21	37.3739
24/08/21	37.3700
25/08/21	37.3666
26/08/21	37.3649
27/08/21	37.3638
28/08/21	37.3643
29/08/21	37.3652
30/08/21	37.3675
31/08/21	37.3702

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 deaths in Saudi Arabia are likely torise up to an equilibrium case volume of approximately 37 deaths per day over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

The study predicts COVID-19 mortality in Saudi Arabia using an artificial intelligence technique. The results of the study indicate that daily COVID-19 mortality cases in the country are likely to hover around 37 deaths per day at peak in the out-of-sample period. This is alarming and a clear warning signal for policy makers. Therefore we encourage authorities in Saudi Arabia to scale up covid-19 vaccination amongst are measures recommended by WHO.

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