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Forecasting Covid-19 Mortality in the Republic of Iran

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 mortality in Iran. The employed data covers the period1 January 2020 to 20 April 2021and 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 Iran are likely to remain very high over the out-of-sample period. Therefore there is need for the Republic of Iran 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 COVID-19 outbreak started in Wuhan City of China in December 2019 (Liu et al, 2020). The rapid spread of the infectious disease was shocking as there was an exponential rise in new cases and hospital admissions. A sudden shortage of medical supplies was inevitable as the first and second waves of COVID-19 hit several countries. Many people had never seen a pandemic of such magnitude before. It was a nightmare for millions of people to find themselves locked down in their homes with no social life and losing their sources of income due to closure of non-essential businesses. WHO named this disease coronavirus disease 19 (COVID-19) after genetic sequencing which showed the same origin of the causative agent with coronaviruses (Ryu et al, 2020; Lai et al, 2020; Rothan & Byra reddy , 2020).One of the most challenging tasks is to construct a model which can accurately predict COVID-19 cases and deaths because of the nature of the virus. The emergence of mutant strains which are more transmissible has made forecasting more complex. However recent studies by Nyoni et al, 2020 and Maradze et al, 2021 have shown that artificial intelligence techniques have better predictive accuracy when compared to traditional statistical and mathematical models. In this study we apply the artificial neural network approach to predict daily COVID-19 deaths in Iran. The results of the study are expected to reveal future trends of COVID-19 mortality in Iran and facilitate resource mobilization needed in the COVID-19 response.

II. LITERATURE REVIEW

A rapid review of COVID-19 epidemic estimation studies for Iran was carried out by Pourmalek et al (2021). The authors searched for and included published articles, preprint manuscripts and reports that estimated numbers of cumulative or daily deaths or cases of COVID-19 in Iran. They found 131 studies and included 29 of them. The study results revealed that there was greater heterogeneity regarding the results of predicted outcomes. Behnam & Jahanmahin (2021) predicted COVID-19 spread in Iran using Machine learning algorithms. The authors compiled a dataset including the number of confirmed cases, the daily number of death cases and the number of recovered cases. The study findings indicated that Gaussian functions show superior performance which is helpful for government to improve its awareness about important factors that have significant impacts on future trends of this virus. Epidemic modeling was applied by Ahmad et al (2020) to model and forecast the trend of COVID-19 epidemic in Iran until May 13, 2020. The daily reports of definitive COVID-19 patients released by Iran Ministry of Health and Medical Education were used in the study. Epidemic projection models of Gompertz, von Bertalanffy, and least squared error (LSE) with percentage error were used to predict the number of hospitalization cases from April 3, 2020 until May 13, 2020. The study concluded that the COVID-19 epidemic would be flat from May 13 until July, 2020 in Iran If enforcement and public behavior interventions were continued. In another similar study, Moein et al (2021) simulated the epidemic in Isfahan province of Iran for the period from Feb 14th to April 11th and also forecasted the remaining course with three scenarios that differed in terms of the stringency level of social distancing. The study results showed that SIR models are based on assumptions that seem not to be true in the case of the COVID-19 epidemic. Hence, more sophisticated modeling strategies and detailed knowledge of the biomedical and epidemiological aspects of the disease are needed to forecast the pandemic. Deep learning approaches were used to predict COVID-19 pandemic in Iran by Kafieh et al (2021). The main goal was to forecast the outbreak

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in nine countries (Iran, Germany, Italy, Japan, Korea, Switzerland, Spain, China, and the USA). The study revealed that the winner model achieved reasonably accurate predictions.

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

Data Issues

This study is based on daily COVID-19 mortality cases in Iran 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	IR
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	0.094507
MSE	651.109206
MAE	21.279134

Residual Analysis for the Applied Model

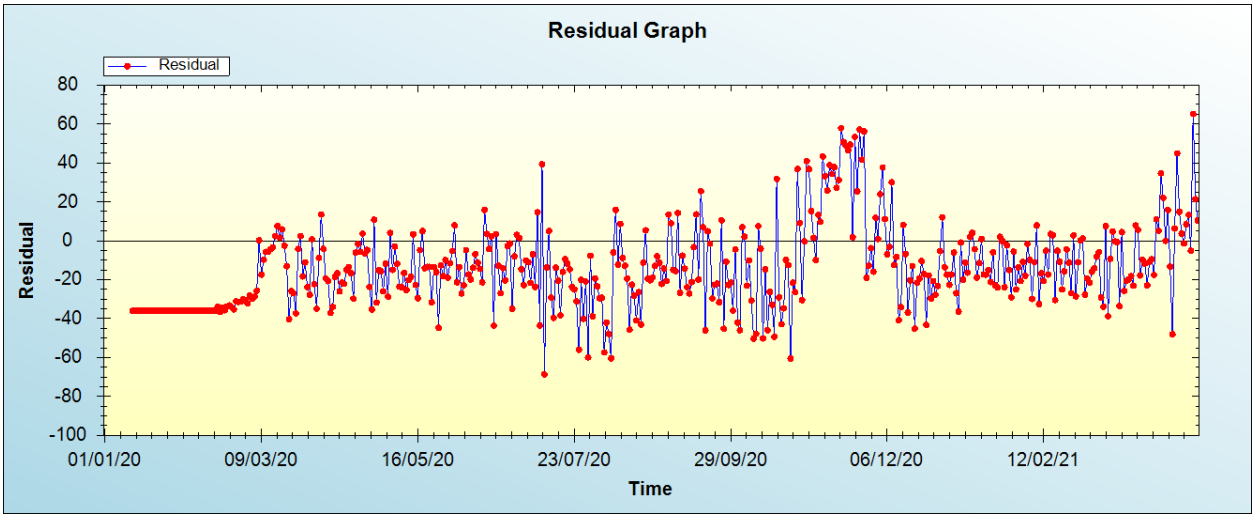

Figure 1: Residual analysis

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In-sample Forecast for IR

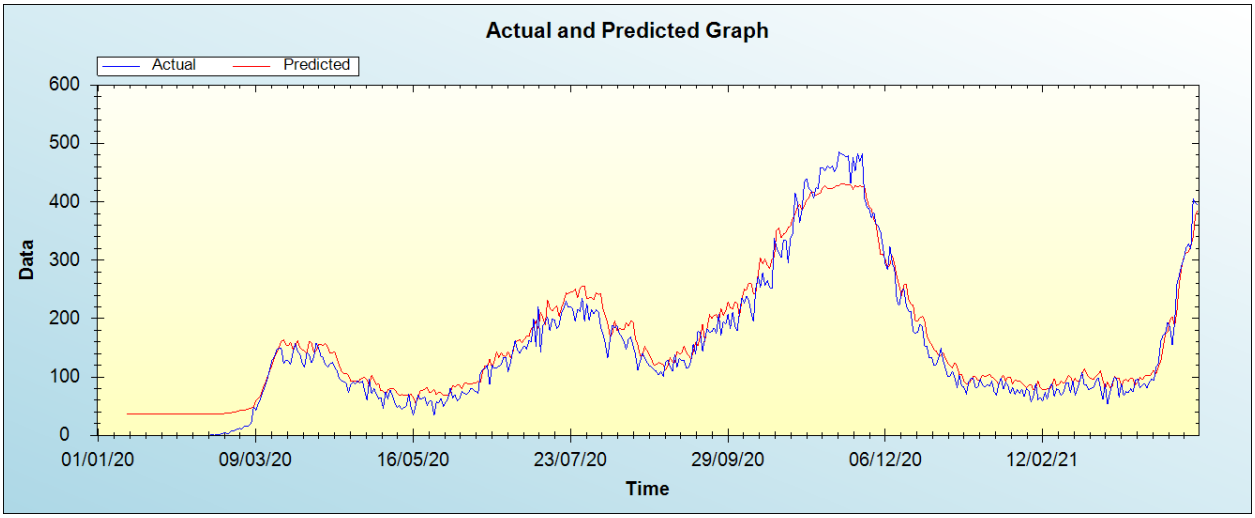

Figure 2: In-sample forecast for the IR series

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

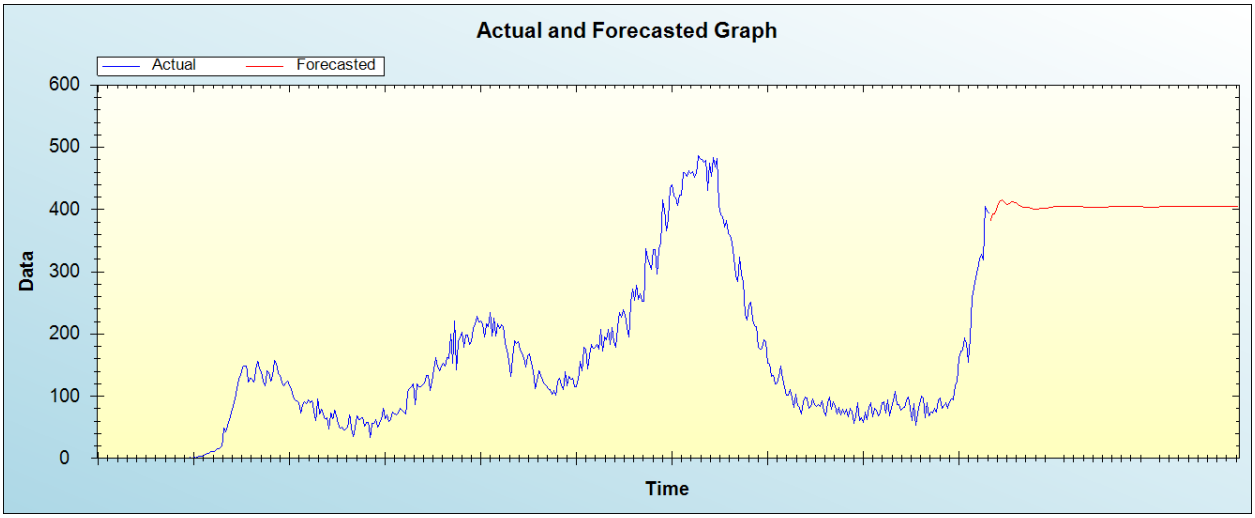

Figure 3: Out-of-sample forecast for IR: actual and forecasted graph

Out-of-Sample Forecast for IR: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Date	Forecasts
21/04/21	382.3397
22/04/21	392.6391
23/04/21	393.1174
24/04/21	399.4902
25/04/21	408.6177
26/04/21	413.9693
27/04/21	414.9308
28/04/21	412.3259
29/04/21	409.1028
30/04/21	408.1132
01/05/21	410.1232
02/05/21	411.8219
03/05/21	412.0183
04/05/21	411.2062
05/05/21	409.3529

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06/05/21	406.8633
07/05/21	404.7980
08/05/21	403.9194
09/05/21	403.9046
10/05/21	403.9415
11/05/21	403.4449
12/05/21	402.3857
13/05/21	401.2341
14/05/21	400.4756
15/05/21	400.3065
16/05/21	400.6582
17/05/21	401.2720
18/05/21	401.8200
19/05/21	402.1260
20/05/21	402.2698
21/05/21	402.4624
22/05/21	402.8539
23/05/21	403.4346
24/05/21	404.0677
25/05/21	404.5977
26/05/21	404.9422
27/05/21	405.1135
28/05/21	405.1877
29/05/21	405.2481
30/05/21	405.3331
31/05/21	405.4187
01/06/21	405.4504
02/06/21	405.3896
03/06/21	405.2396
04/06/21	405.0387
05/06/21	404.8345
06/06/21	404.6584
07/06/21	404.5144
08/06/21	404.3871
09/06/21	404.2585
10/06/21	404.1234
11/06/21	403.9930
12/06/21	403.8865
13/06/21	403.8184
14/06/21	403.7907
15/06/21	403.7941
16/06/21	403.8150
17/06/21	403.8439
18/06/21	403.8785
19/06/21	403.9216
20/06/21	403.9766
21/06/21	404.0429
22/06/21	404.1149
23/06/21	404.1849
24/06/21	404.2466
25/06/21	404.2971
26/06/21	404.3373
27/06/21	404.3694
28/06/21	404.3950
29/06/21	404.4138
30/06/21	404.4244
01/07/21	404.4257
02/07/21	404.4177
03/07/21	404.4022
04/07/21	404.3819
05/07/21	404.3593
06/07/21	404.3360
07/07/21	404.3125
08/07/21	404.2892

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09/07/21	404.2664
10/07/21	404.2451
11/07/21	404.2263
12/07/21	404.2110
13/07/21	404.1999
14/07/21	404.1927
15/07/21	404.1890
16/07/21	404.1882
17/07/21	404.1900
18/07/21	404.1940
19/07/21	404.2001
20/07/21	404.2079
21/07/21	404.2168
22/07/21	404.2263
23/07/21	404.2358
24/07/21	404.2447
25/07/21	404.2527
26/07/21	404.2598
27/07/21	404.2658
28/07/21	404.2706
29/07/21	404.2741
30/07/21	404.2763
31/07/21	404.2771
01/08/21	404.2767
02/08/21	404.2753
03/08/21	404.2732
04/08/21	404.2704
05/08/21	404.2672
06/08/21	404.2638
07/08/21	404.2603
08/08/21	404.2569
09/08/21	404.2537
10/08/21	404.2508
11/08/21	404.2483
12/08/21	404.2463
13/08/21	404.2449
14/08/21	404.2439
15/08/21	404.2434
16/08/21	404.2434
17/08/21	404.2437
18/08/21	404.2444
19/08/21	404.2454
20/08/21	404.2465
21/08/21	404.2478
22/08/21	404.2491
23/08/21	404.2505
24/08/21	404.2517
25/08/21	404.2528
26/08/21	404.2538
27/08/21	404.2546
28/08/21	404.2553
29/08/21	404.2557
30/08/21	404.2560
31/08/21	404.2560

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 Iran are likely to remain very high over the out-of-sample period.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Iran is one of the top 10 countries in the world which have been seriously affected by the COVID-19 pandemic. Many researchers around the globe have applied deep learning approaches to predict COVID-19 cases and deaths. Examples of such

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approaches include artificial neural networks (ANNs), ensembles, Bayesian networks and support vector machines. The Multilayer perceptron (MLP) is a popular neural network, which utilizes several nonlinear transformations to make a prediction. In this study, the applied ANN (12, 12, 1) model has three layers of nodes, the input features are called the input layer, and the intermediate transformations are called the hidden layer (Zhang, 2003). The outputs of the first layer (input) are used as the inputs of the next layer (hidden). The output of the hidden layer is used as the input of the output layer. All nodes in hidden layers use a nonlinear activation function. The ANN model in this paper was used to predict daily COVID-19 mortality in Iran. The model predictions suggest that daily COVID-19 mortality cases in Iran are likely to remain very high over the out-of-sample period. Therefore we encourage the Iranian government to accelerate COVID-19 vaccination amongst other measures recommended by WHO.

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