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Forecasting Covid-19 Deaths in Slovenia

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 deaths in Slovenia. This study is based on daily COVID-19 deaths in Slovenia 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 Slovenia are likely to continue to rise up to an equilibrium level of 53 deaths per day over the out-of-sample period. Amongst other suggested policy directions, there is need for the government of Slovenia to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and to expand the vaccination programme.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The use of artificial intelligence (AI) techniques in the analysis of big data has gained popularity in many fields including medicine (Khemasuwan et al, 2020). The technology has transformed healthcare delivery as many AI applications are being utilized in screening of health conditions, prognosis, diagnosis and prediction of diseases in order to improve the quality of healthcare in private and public health institutions (Panch et al, 2018). The use of AI technologies is a concept that started at the Dartmouth College in 1956 and the concept was fine tuned in the 1980s and then applied in the medicine (Grosan et al, 2011; Snow et al, 19988; Pan et al, 1985; Alkins et al, 1983). In public health several machine learning methods have been applied such as artificial neural networks, tree-based models, support vector machine, K-nearest neighbors, and graphical models (Nyoni et al, 2020; Zhao et al, 2020). In machine learning the algorithm learns the relationship between the input and output variables and comes up with a function which best describes the relationship. This function is referred to as the hypothesis or predictor function and thus will be used for prediction of future output values. Learning can be supervised or unsupervised. Supervised learning occurs when the algorithm learns a predictor function when both input and output values are provided by the supervisor whereas in unsupervised learning the algorithm discovers the hidden structures or patterns in the input data (Weng et al, 2017). In this paper we apply the multilayer perceptron neural network which performs supervised learning to predict daily COVID-19 deaths in Slovenia. The back propagation algorithm is utilized in the training process (Nyoni et al, 2021; Fojnica et al, 2016; Zhang, 2003; Kishan, 1997; Patterson, 1995). The results of the study are expected to reveal future trends of COVID-19 related deaths in Slovenia and facilitate planning and allocation of resources in order to fight the epidemic in the country.

II. METHODOLOGY

TheArtificialNeuralNetwork(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 inSlovenia.

Data Issues

This study is based on daily COVID-19 deaths in Slovenia 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	S
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	0.090307
MSE	10.964457
MAE	2.345790

Residual Analysis for the Applied Model

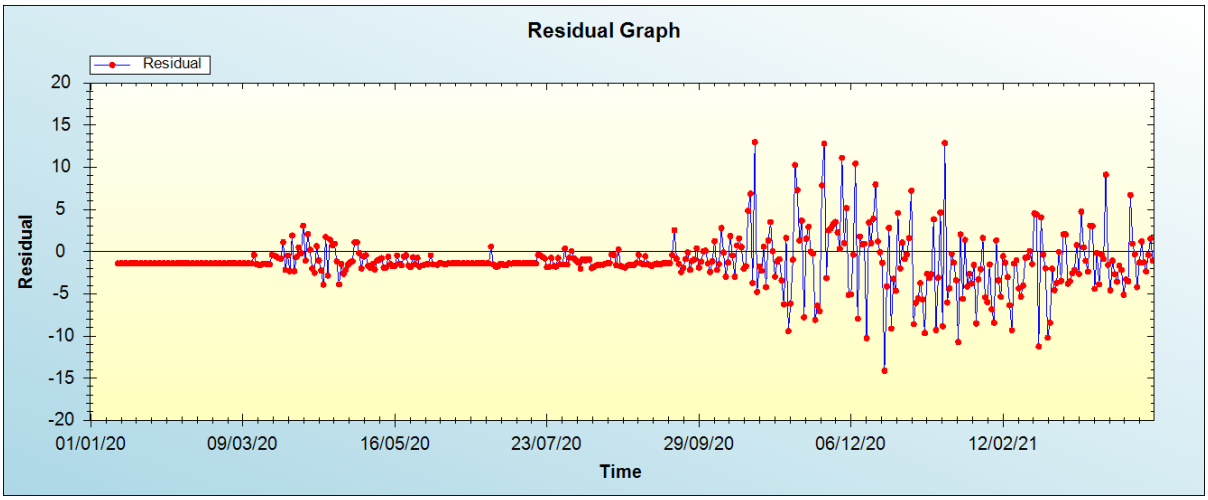

Figure 1: Residual analysis

In-sample Forecast for S

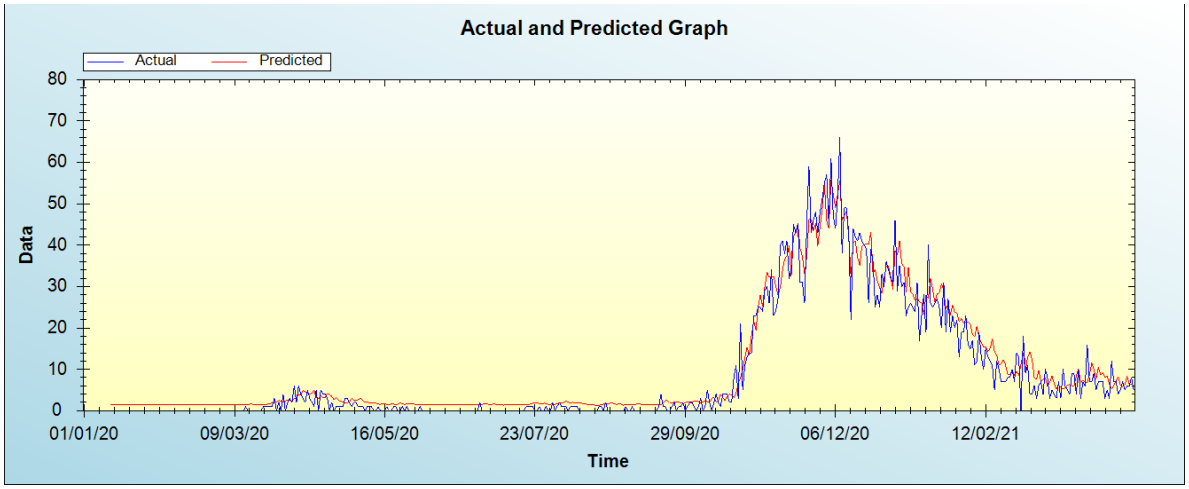

Figure 2: In-sample forecast for the S series

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

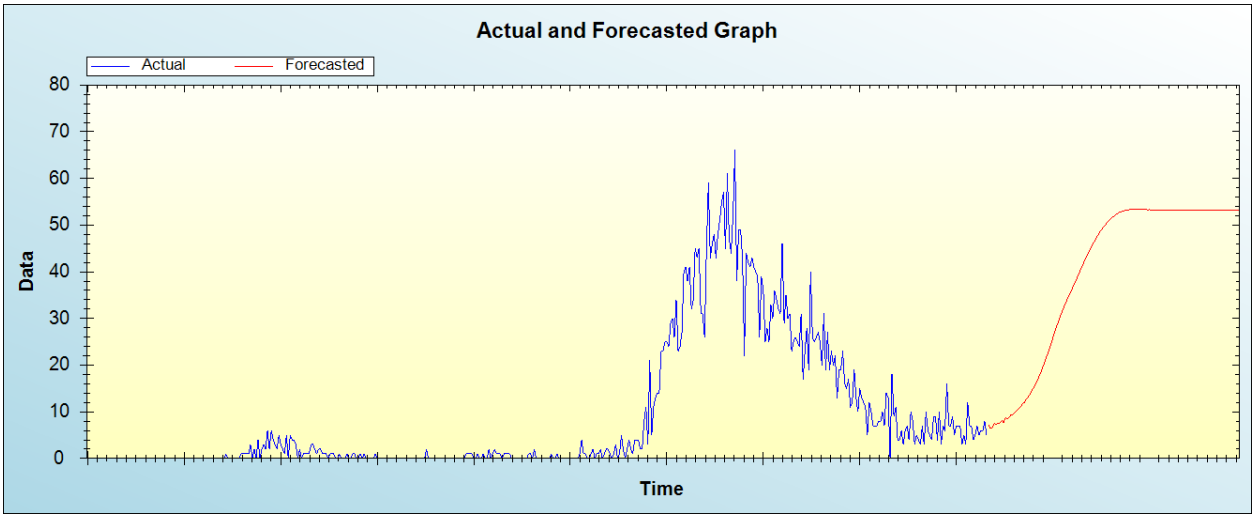

Figure 3: Out-of-sample forecast for S: actual and forecasted graph

Out-of-Sample Forecast for S: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Date	Forecasts
21/04/21	7.1975
22/04/21	6.4149
23/04/21	6.6218
24/04/21	7.5288
25/04/21	7.1477
26/04/21	7.5755
27/04/21	7.5761
28/04/21	8.1431
29/04/21	7.7013
30/04/21	8.7884
01/05/21	8.5107
02/05/21	8.9688
03/05/21	9.3744
04/05/21	9.4577
05/05/21	9.9455
06/05/21	10.2472
07/05/21	10.7662
08/05/21	11.0075
09/05/21	11.7741
10/05/21	11.9527
11/05/21	12.6898
12/05/21	13.2041
13/05/21	13.8123
14/05/21	14.5735
15/05/21	15.2639
16/05/21	16.0890
17/05/21	16.8690
18/05/21	17.8902
19/05/21	18.7153
20/05/21	19.9242
21/05/21	20.9190
22/05/21	22.1409
23/05/21	23.3088
24/05/21	24.5530
25/05/21	25.7739
26/05/21	27.0522

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27/05/21	28.2325
28/05/21	29.4504
29/05/21	30.5015
30/05/21	31.6071
31/05/21	32.5411
01/06/21	33.5417
02/06/21	34.4137
03/06/21	35.3561
04/06/21	36.1843
05/06/21	37.1166
06/06/21	37.9424
07/06/21	38.9191
08/06/21	39.7630
09/06/21	40.7686
10/06/21	41.6089
11/06/21	42.5770
12/06/21	43.3659
13/06/21	44.2829
14/06/21	45.0028
15/06/21	45.8560
16/06/21	46.4943
17/06/21	47.2904
18/06/21	47.8497
19/06/21	48.5773
20/06/21	49.0861
21/06/21	49.7400
22/06/21	50.1652
23/06/21	50.7354
24/06/21	51.0830
25/06/21	51.5577
26/06/21	51.8148
27/06/21	52.2163
28/06/21	52.3957
29/06/21	52.6922
30/06/21	52.8099
01/07/21	53.0397
02/07/21	53.0860
03/07/21	53.2437
04/07/21	53.2586
05/07/21	53.3645
06/07/21	53.3251
07/07/21	53.4023
08/07/21	53.3591
09/07/21	53.3941
10/07/21	53.3342
11/07/21	53.3746
12/07/21	53.3121
13/07/21	53.3252
14/07/21	53.2765
15/07/21	53.3051
16/07/21	53.2444
17/07/21	53.2641
18/07/21	53.2340
19/07/21	53.2527
20/07/21	53.2072
21/07/21	53.2387
22/07/21	53.2170
23/07/21	53.2285
24/07/21	53.2019
25/07/21	53.2382
26/07/21	53.2131
27/07/21	53.2231
28/07/21	53.2143
29/07/21	53.2421

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30/07/21	53.2124
31/07/21	53.2287
01/08/21	53.2283
02/08/21	53.2400
03/08/21	53.2133
04/08/21	53.2388
05/08/21	53.2343
06/08/21	53.2325
07/08/21	53.2190
08/08/21	53.2467
09/08/21	53.2303
10/08/21	53.2267
11/08/21	53.2289
12/08/21	53.2472
13/08/21	53.2215
14/08/21	53.2284
15/08/21	53.2379
16/08/21	53.2391
17/08/21	53.2162
18/08/21	53.2369
19/08/21	53.2397
20/08/21	53.2275
21/08/21	53.2200
22/08/21	53.2454
23/08/21	53.2323
24/08/21	53.2208
25/08/21	53.2312
26/08/21	53.2462
27/08/21	53.2211
28/08/21	53.2243
29/08/21	53.2419
30/08/21	53.2370
31/08/21	53.2150

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 Slovenia are likely to continue to rise up to an equilibrium level of 53 deaths per day over the out-of-sample period.

IV. CONCLUSION AND POLICY RECOMMENDATIONS

The COVID-19 pandemic has brought too much fear and uncertainties all over the world. Many investors are holding onto their money due to concerns over the suitability of the period to do massive investments when several economies are on their down turn. At the moment many resources are being channeled to COVID-19 prevention and control leaving other important issues unattended. Projections of COVID-19 cases will facilitate proper planning and allocation of resources. Therefore in this study we applied the artificial neural network approach to predict daily COVID-19 deaths in Slovenia. The results of the study indicate that daily COVID-19 deaths in Slovenia are likely to continue to rise up to an equilibrium level of 53 deaths per day over the out-of-sample period.Amongst other suggested policy directions, there is need for the government of Slovenia to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and to expand the vaccination programme.

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