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Forecasting Covid-19 New Cases in Estonia

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***Abstract* - In this study, the ANN approach was applied to analyze COVID-19 new cases in Estonia. The employed data covers the period 1 January 2020 – 25 March 2021 and the out-of-sample period ranges over the period 26 March – 31 July 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 cases are likely to remain very high over the out-of-sample period. Amongst other suggested policy directions, there is need for the government of Estonia to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

Machine learning (ML) is a sub discipline of artificial intelligence (AI) and is a scientific field which focuses on the ability of computers to learn through experience (Weng et al, 2017). The computer learns a hypothesis function or learns the relationship between variables and then makes predictions. Different algorithms have been applied by researchers such as artificial neural networks (ANNs), support vector machine (SVM), K-nearest neighbors (KNNs), ensembles (tree-based models) and graphical models (Bayesian networks) (Nyoni et al, 2020; Zhao et al, 2020; Weng et al, 2017). ANNs are widely used in time series forecasting problems and have been utilized in applications such as pattern recognition, function approximation, prediction and time series forecasting. The multilayer perceptron (MLP) is the most widely used ANN framework (Zhang, 2003).The model is composed of 3 layers of neurons: input layer, hidden layer and output layer connected by acyclic links called weights (Zhao et al, 2020, Makridakis, 2018; Kawushik & Sahi, 2018;Fojnica et al, 2016; Zhang, 2003). In this paper we apply the ANN (12, 12, 1) model to predict daily COVID-19 cases in Estonia. The findings of this piece of work will provide an insight of the likely future trends of daily new COVID-19 cases in Estonia and stimulate an evidence based response to the pandemic and minimize the effects of the SARS-COV2 virus and curb its spread.

II. LITERATURE REVIEW

Artificial intelligence techniques have been applied by many researchers to predict COVID-19 cases and mortality rates. The ANN (12, 12, 1) model was utilized by Nyoni et al (2020) to predict daily COVID-19 cases in Canada using daily COVID-19 data from Johns Hopkins University from the period January 26, 2020 to 31 October, 2020 and the out of-sample period ranging over the period November 2020 to April 20. The study revealed that daily COVID-19 cases would generally increase until around December 14, 2020 where an equilibrium daily case volume of almost 2965 cases would be reached and this daily equilibrium case volume was likely to be persistent throughout the rest of the out-of-sample period. Based on the multilayer perceptron Car et al (2020) forecasted the spread of COVID-19 Croatia. Best models achieved consisted of 4 hidden layers with 4 neurons in each of those layers, and used a ReLU activation function, with R2 scores of 0.98599 for confirmed, 0.99429 for deceased, and 0.97941 for recovered patient models. Some studies have employed survival modeling techniques to analyze COVID-19 data. By applying the Cox Proportional Hazard model, Fisman et al (2020) found out that age and pre-existing chronic medical conditions (especially diabetes, renal disease and immune compromise) were strong predictors of mortality.

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 new COVID-19 cases Estonia.

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Data Issues

This study is based on daily new cases of COVID-19 in Estonia for the period 1 January 2020 – 25 March 2021. The out-of-sample forecast covers the period 26 March 2021 – 31 July 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	E
Observations	438 (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	0.065360
MSE	5044.501150
MAE	42.282938

Residual Analysis for the Applied Model

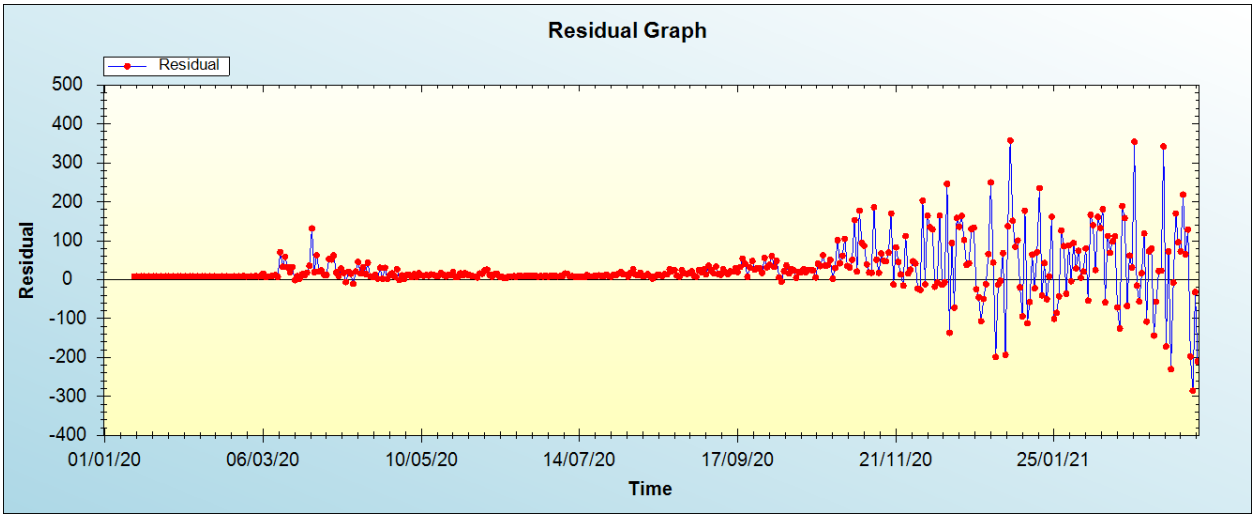

Figure 1: Residual analysis

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In-sample Forecast for E

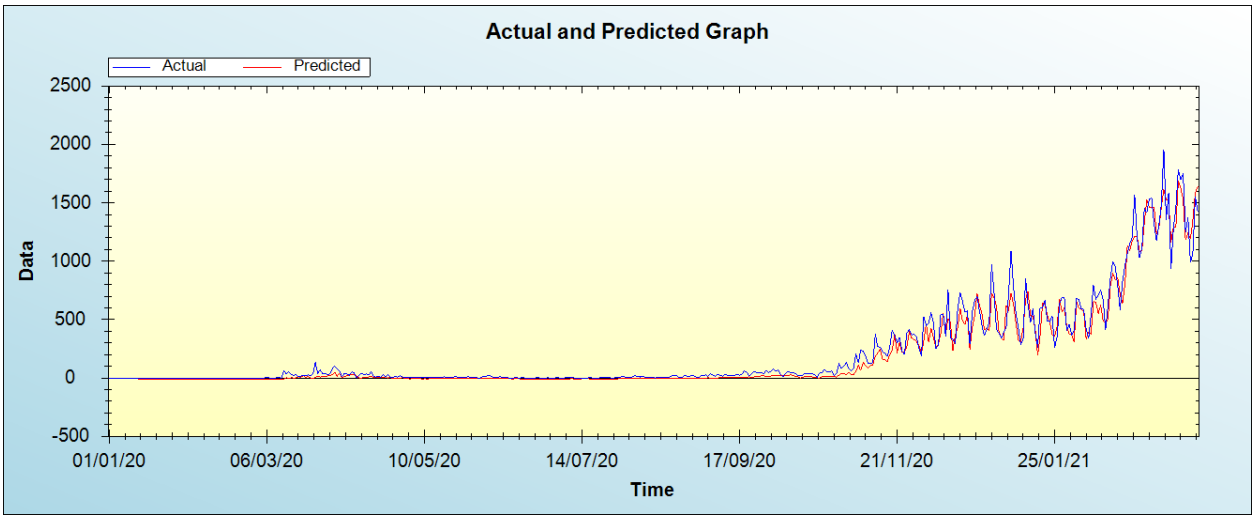

Figure 2: In-sample forecast for the E series

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

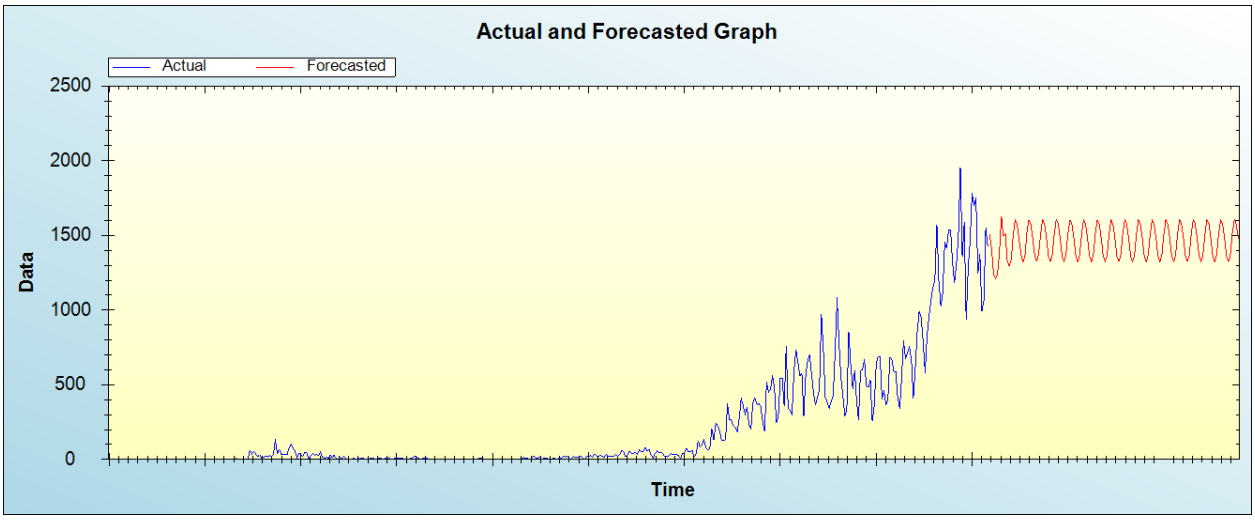

Figure 3: Out-of-sample forecast for E: actual and forecasted graph

Out-of-Sample Forecast for E: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
26/03/21	1504.2059
27/03/21	1412.6522
28/03/21	1241.6106
29/03/21	1211.9509
30/03/21	1242.3369
31/03/21	1392.2469
01/04/21	1628.8231
02/04/21	1493.6803
03/04/21	1512.1320
04/04/21	1329.3763
05/04/21	1293.0555
06/04/21	1336.3713
07/04/21	1499.0647

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08/04/21	1605.6417
09/04/21	1576.0457
10/04/21	1473.5167
11/04/21	1374.5659
12/04/21	1320.5693
13/04/21	1360.2497
14/04/21	1517.7500
15/04/21	1603.2366
16/04/21	1577.3388
17/04/21	1481.7986
18/04/21	1365.7353
19/04/21	1325.4627
20/04/21	1369.7475
21/04/21	1508.1096
22/04/21	1607.6646
23/04/21	1574.4082
24/04/21	1483.9609
25/04/21	1363.9184
26/04/21	1324.3136
27/04/21	1369.0916
28/04/21	1509.6412
29/04/21	1605.0894
30/04/21	1576.8259
01/05/21	1482.1406
02/05/21	1363.8275
03/05/21	1323.9349
04/05/21	1368.5560
05/05/21	1510.1218
06/05/21	1605.1321
07/05/21	1576.5651
08/05/21	1482.4320
09/05/21	1363.1340
10/05/21	1323.7057
11/05/21	1368.7780
12/05/21	1509.8811
13/05/21	1605.5024
14/05/21	1576.3403
15/05/21	1482.3722
16/05/21	1362.9256
17/05/21	1323.5455
18/05/21	1368.7176
19/05/21	1510.1537
20/05/21	1605.4806
21/05/21	1576.3814
22/05/21	1482.1348
23/05/21	1362.7756
24/05/21	1323.4541
25/05/21	1368.7349
26/05/21	1510.3436
27/05/21	1605.5588
28/05/21	1576.3011
29/05/21	1481.9923
30/05/21	1362.6021
31/05/21	1323.3884
01/06/21	1368.8119
02/06/21	1510.5081
03/06/21	1605.6327
04/06/21	1576.2236
05/06/21	1481.8325
06/06/21	1362.4587
07/06/21	1323.3420
08/06/21	1368.8925
09/06/21	1510.6994
10/06/21	1605.6811

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11/06/21	1576.1538
12/06/21	1481.6659
13/06/21	1362.3257
14/06/21	1323.3092
15/06/21	1368.9892
16/06/21	1510.8881
17/06/21	1605.7289
18/06/21	1576.0757
19/06/21	1481.5036
20/06/21	1362.1982
21/06/21	1323.2853
22/06/21	1369.0967
23/06/21	1511.0771
24/06/21	1605.7723
25/06/21	1575.9962
26/06/21	1481.3407
27/06/21	1362.0769
28/06/21	1323.2680
29/06/21	1369.2102
30/06/21	1511.2679
01/07/21	1605.8118
02/07/21	1575.9157
03/07/21	1481.1778
04/07/21	1361.9597
05/07/21	1323.2554
06/07/21	1369.3284
07/07/21	1511.4587
08/07/21	1605.8491
09/07/21	1575.8341
10/07/21	1481.0155
11/07/21	1361.8455
12/07/21	1323.2461
13/07/21	1369.4500
14/07/21	1511.6495
15/07/21	1605.8846
16/07/21	1575.7520
17/07/21	1480.8535
18/07/21	1361.7336
19/07/21	1323.2393
20/07/21	1369.5736
21/07/21	1511.8400
22/07/21	1605.9187
23/07/21	1575.6695
24/07/21	1480.6919
25/07/21	1361.6236
26/07/21	1323.2341
27/07/21	1369.6988
28/07/21	1512.0302
29/07/21	1605.9517
30/07/21	1575.5869
31/07/21	1480.5308

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 cases in Estonia are likely to remain very high over the out-of-sample period.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Coronavirus disease-19 (COVID-19) currently is the worst global health problem which has surprisingly led to the death of many people across the globe. Prediction of the evolution of the disease is critical in healthcare planning as this provides an insight of the future trends of the virus and facilitate decision making and allocation of resources to control the spread of the highly infectious virus. In this piece of work we predicted daily confirmed COVID-19 cases in Estonia using the artificial neural

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network approach. The results of the study indicate that COVID-19 cases in the country are likely to remain very high over the out-of-sample period. Therefore we encourage the government to continue enforcing adherence to COVID-19 public health mitigation measures.

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