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Forecasting Covid-19 Mortality in France Using Artificial Neural Networks

[1]Dr. Smartson. P. NYONI, [2]Thabani NYONI, [3]Tatenda. A. CHIHOHO

[1]ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe
[2]SAGIT Innovation Centre, Harare, Zimbabwe
[3]Independent Researcher, Harare, Zimbabwe

***Abstract* - In this research paper, the ANN approach was applied to analyze daily COVID-19 deaths in France. The employed daily data covers the period to 1 January 2020 to 31 December 2020 and the out-of-sample period ranges over the period to 1January 2021 to 31 May 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting daily COVID-19 cases in France. The applied ANN (12, 12, 1) model projections indicate that COVID-19 mortality will generally rise in the out-of-sample period, up to approximately 710 deaths per day over the month of May 2021.Therefore the government of France is encouraged to continue applying WHO guidelines on prevention and control of COVID-19 including COVID-19 mass vaccination in order to achieve herd immunity.**

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

Artificial neural networks (ANNs) are computational tools that are utilized in solving many complex real world problems including in public health (Zhao et al, 2020; Weng et al, 2017; Fojnica et al, 2016). ANNs have gained prominence in public health because of their excellent information processing attributes of the biological system such as nonlinearity, high parallelism, robustness, fault and failure tolerance, ability to handle imprecise and fuzzy information and their ability to generalize (Weng et al,2017; Zhang, 2003). The objective of ANN based computing is to develop mathematical algorithms that enable ANNs to learn by mimicking the human brain (Zhang,2003; Kishan, 1997; Patterson, 1995).ANNs applications are many and include time series modeling, classification, pattern recognition and multivariate data analysis (Basheer& Hajmeer, 2000). The multilayer perceptron, recurrent neural network, radial basis function and generalized regression neural network are the common artificial neural frameworks. The multilayer perceptron (MLP) is the widely used neural network framework in time series forecasting (Nyoni et al, 2020; Zhao et al, 2020; Arora et al, 2020; Yan et al, 2018; Kolter & Koltun, 2018; Kaushik & Sahi, 2018; Paswan et al, 2018; Ruder, 2017; Fojnica et al, 2016; Quazi et al, 2015; Raghupathi &Raghupathi, 2015; Schmidhuber, 2014;Gomes et al, 2011; Yan et al, 2006;Ozkan et al, 2003; Zhang, 2003; Kishan, 1997; Patterson, 1995). It is made up of 3layers of nodes namely input layer, hidden layer and output layer.In this paper we applied the MLP, ANN (12, 12, 1) to model and forecast daily COVID-19 deaths in France. The results are expected to reveal future trends of COVID-19 mortality in France and help in the assessment of the impact of COVID-19 prevention and control measures including the vaccination program.

II. METHODOLOGY

The Artificial Neural Network (ANN), which we intend to apply in this study; is a data processing system consisting of a huge number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from any data-set to 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 France 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.

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III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	H
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	0.117408
MSE	11624.991086
MAE	81.839472

Residual Analysis for the Applied Model

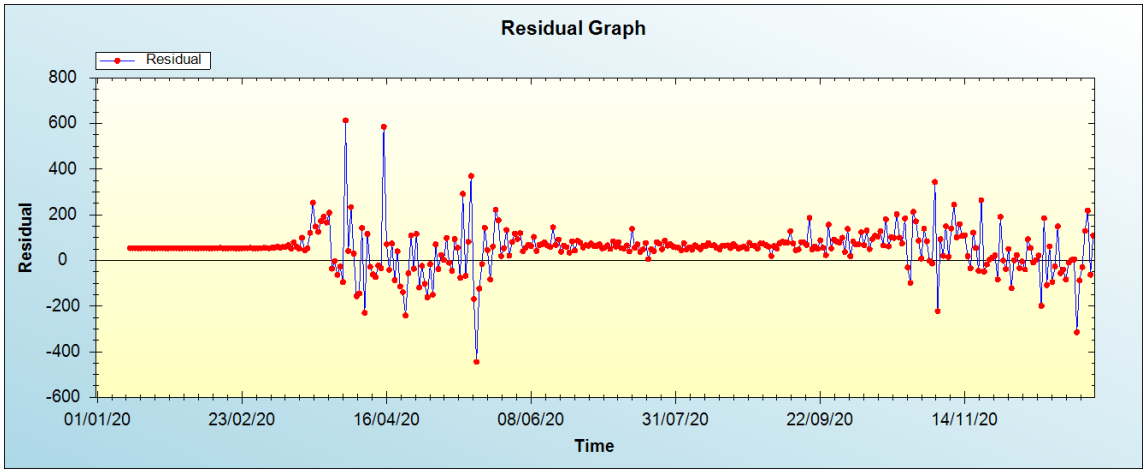

Figure 1: Residual analysis

In-sample Forecast for H

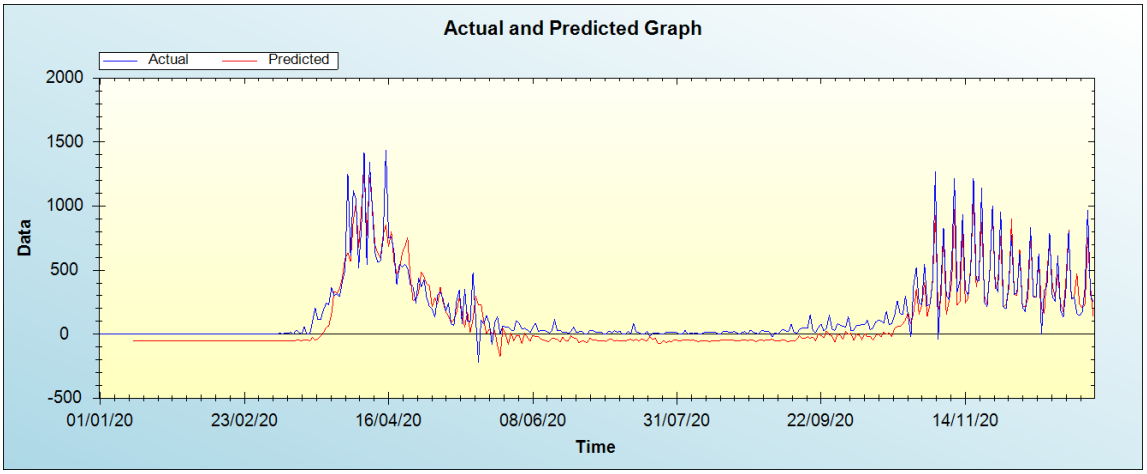

Figure 2: In-sample forecast for the H series

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

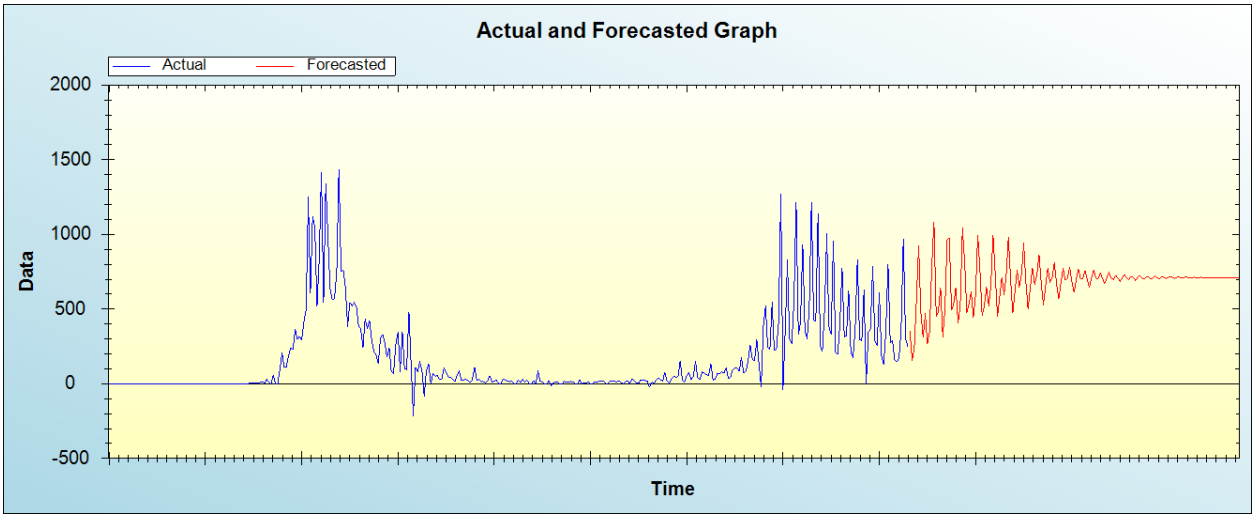

Figure 3: Out-of-sample forecast for H: actual and forecasted graph

Out-of-Sample Forecast for H: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Date	Forecast
01/01/21	351.7897
02/01/21	154.2309
03/01/21	244.2542
04/01/21	571.2070
05/01/21	924.6566
06/01/21	477.4434
07/01/21	310.1899
08/01/21	469.2525
09/01/21	267.9598
10/01/21	353.1503
11/01/21	780.2418
12/01/21	1081.2387
13/01/21	453.1546
14/01/21	483.8985
15/01/21	643.7916
16/01/21	314.9916
17/01/21	500.0433
18/01/21	961.1696
19/01/21	977.9990
20/01/21	493.0645
21/01/21	534.5731
22/01/21	644.2000
23/01/21	405.6251
24/01/21	526.0120
25/01/21	1042.4799
26/01/21	825.8488
27/01/21	477.0683
28/01/21	537.4062
29/01/21	618.0728
30/01/21	443.3063
31/01/21	592.0665
01/02/21	994.9667
02/02/21	765.7794

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03/02/21	456.8562
04/02/21	523.6942
05/02/21	646.8228
06/02/21	521.0166
07/02/21	655.9844
08/02/21	993.9235
09/02/21	731.6048
10/02/21	449.8897
11/02/21	576.3811
12/02/21	710.0228
13/02/21	596.0202
14/02/21	716.6213
15/02/21	982.1918
16/02/21	702.5217
17/02/21	472.7513
18/02/21	621.4589
19/02/21	763.1994
20/02/21	647.2791
21/02/21	731.1215
22/02/21	940.2858
23/02/21	681.3545
24/02/21	497.9675
25/02/21	644.8450
26/02/21	778.0537
27/02/21	666.4049
28/02/21	723.3222
01/03/21	865.7961
02/03/21	671.8939
03/03/21	528.4070
04/03/21	653.5246
05/03/21	775.3483
06/03/21	679.4066
07/03/21	708.9463
08/03/21	812.2605
09/03/21	674.7152
10/03/21	566.1674
11/03/21	676.0576
12/03/21	771.2583
13/03/21	692.3569
14/03/21	705.8797
15/03/21	779.6000
16/03/21	687.1924
17/03/21	611.0498
18/03/21	697.0812
19/03/21	769.2085
20/03/21	703.6919
21/03/21	704.5052
22/03/21	759.0254
23/03/21	701.0323
24/03/21	646.7175
25/03/21	709.5836
26/03/21	759.6251
27/03/21	708.5593
28/03/21	701.8084
29/03/21	739.8309
30/03/21	708.5160
31/03/21	669.5768
01/04/21	710.8957

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02/04/21	746.1194
03/04/21	708.6807
04/04/21	697.7980
05/04/21	725.9232
06/04/21	710.5842
07/04/21	683.1096
08/04/21	709.5524
09/04/21	734.0699
10/04/21	708.1323
11/04/21	697.1973
12/04/21	717.8628
13/04/21	711.9904
14/04/21	692.7672
15/04/21	708.9602
16/04/21	726.7847
17/04/21	708.8574
18/04/21	699.4294
19/04/21	714.7767
20/04/21	713.4910
21/04/21	699.9249
22/04/21	709.5716
23/04/21	722.1433
24/04/21	710.1381
25/04/21	702.3942
26/04/21	713.3418
27/04/21	714.2884
28/04/21	704.4630
29/04/21	709.7476
30/04/21	718.6279
01/05/21	710.6650
02/05/21	704.5066
03/05/21	712.1807
04/05/21	713.8481
05/05/21	706.8248
06/05/21	709.4091
07/05/21	715.6403
08/05/21	710.6109
09/05/21	705.8631
10/05/21	711.1340
11/05/21	713.0213
12/05/21	708.0284
13/05/21	709.1131
14/05/21	713.5726
15/05/21	710.5067
16/05/21	707.0011
17/05/21	710.5894
18/05/21	712.3648
19/05/21	708.8999
20/05/21	709.1847
21/05/21	712.3755
22/05/21	710.6220
23/05/21	708.0486
24/05/21	710.4464
25/05/21	711.9758
26/05/21	709.5680
27/05/21	709.4495
28/05/21	711.7124
29/05/21	710.7467

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30/05/21	708.8710
31/05/21	710.4134

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 mortality will generally rise in the out-of-sample period, up to approximately 710 deaths per day over the month of May 2021.

IV. CONCLUSION &RECOMMENDATIONS

Artificial neural networks (ANNs) have been successfully applied in modeling and forecasting COVID-19 infections and fatalities by many researchers all over the World. The artificial intelligence technique has produced reliable results in time series forecasting especially its capability to analyze large and complex data sets like the daily COVID-19 cases (Nyoni et al, 2020). The multilayer perceptron was applied in this paper to model COVID-19 mortality in France and the model projections suggested that COVID-19 fatality will generally rise in the out of sample period. Therefore the French authorities are strongly encouraged to speed up COVID-19 mass vaccination amongst other control measures.

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