Forecasting Covid-19 Mortality in Morocco

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Abstract - **In this study, the ANN approach was applied to analyze COVID-19 deaths in Morocco. The employed data covers the period 1 January 2020 to 20 April 2021 and the out-of-sample period ranges over the period 21 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 deaths in Morocco are likely to be less than 10 deaths over the out-of-sample period. Therefore there is need for the government of Morocco to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and encourage people to be vaccinated against COVID-19.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

The COVID-19 pandemic is one of the most troublesome global health crisis that has ever affected humankind. It emanated in Wuhan, China in December 2019 and it is known to be caused by a new type of coronavirus recently named SARS-COV2 (Gorbalenya et al, 2020). The disease was declared by WHO as a pandemic on the 11th of March 2020 (WHO, 2020). The novel coronavirus SARS-COV2 has not been previously detected in humans and symptoms of the clinical disease include fever, dry cough, breathing difficulties, chest pains, and loss of sense of taste or smell. The severe clinical disease is characterized by severe acute respiratory syndrome and kidney failure or death (WHO, 2020). The first case of COVID-19 in Morocco was detected on the 2nd of March 2020 in the city of Casablanca (Mahrouf, 2021; MOH Morocco, 2020). The Moroccan government responded well to the COVID-19 epidemic by closing its borders, closure of schools, universities and non-essential businesses and shut down of all mosques in the country (Zine et al, 2020).In this study we aim to predict daily COVID-19 mortality in Morocco using an artificial intelligence technique. The results of the study will provide an insight of the likely future trends of COVID-19 deaths in the country and help in prediction of the negative health impact of the COVID-19 epidemic in Morocco.

II. LITERATURE REVIEW

The spread of COVID-19 in Morocco was modeled and forecasted by Mahrouf et al (2021). The study applied the SIR compartmental model to deterministic and stochastic time-delayed models in order to predict the epidemiological trend of COVID-19 in Morocco and to assess the potential role of multiple preventive measures and strategies imposed by Moroccan authorities. Parameter values were estimated from real data and numerical simulations were presented for forecasting the COVID-19 spreading as well as verification of theoretical results. The study concluded that the measures taken against COVID-19 in Morocco encourage their maintenance to control the spread of the epidemic and quickly move towards extinction. Zakary et al (2020) proposed a discrete-time mathematical model describing the evolution of the COVID-19 in a population under quarantine. The study was motivated by the growing numbers of infections and deaths in countries under quarantine to investigate potential causes. Authors considered two new classes of people, those who respect the quarantine and stay at home, and those who do not respect the quarantine and leave their homes for one or another reason. They utilized real published data to estimate the parameters of the model, and then estimated these populations in Morocco. The study results revealed that the population at risk in Morocco was more than 10 million individuals in the first month of the closure, and then the need for an efficient control strategy to save more lives. In another similar study, Zine et al (2020)proposed a delayed mathematical model to predict the epidemiological trend of COVID-19 in Morocco. Parameter estimation and sensitivity analysis of the proposed model were rigorously studied. The study concluded that increasing the level of the lockdown accompanied by the general use of the face masks was the best option to be taken by Moroccan authorities in order to curb the spread of COVID-19.

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 deaths in Morocco.

Data Issues

This study is based on daily COVID-19 deaths in Morocco 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	MR
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	0.755569
MSE	14.976347
MAE	2.917455

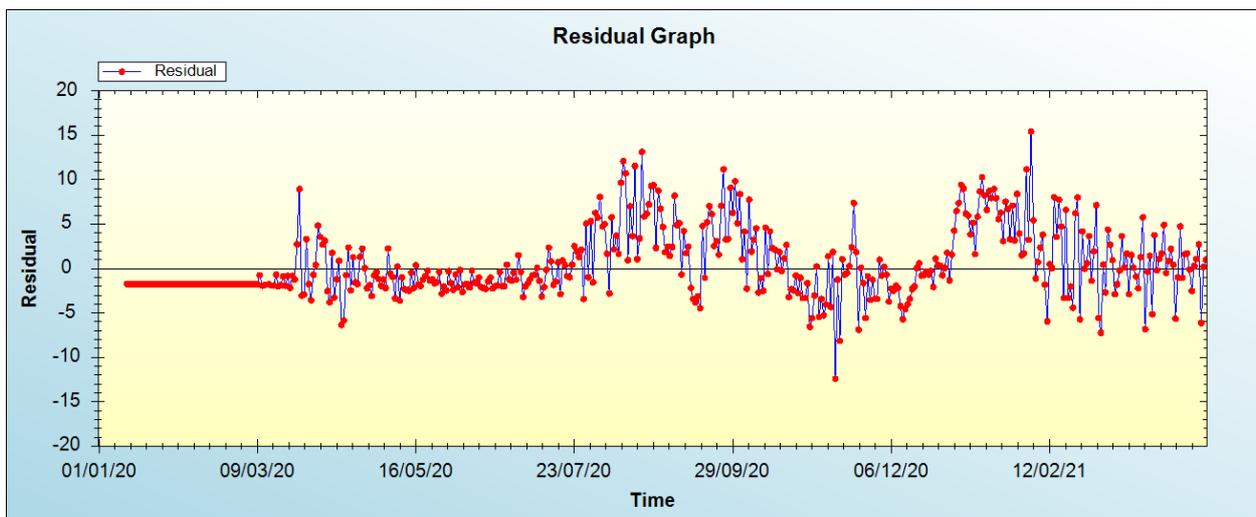Residual Analysis for the Applied Model

Figure 1: Residual analysis
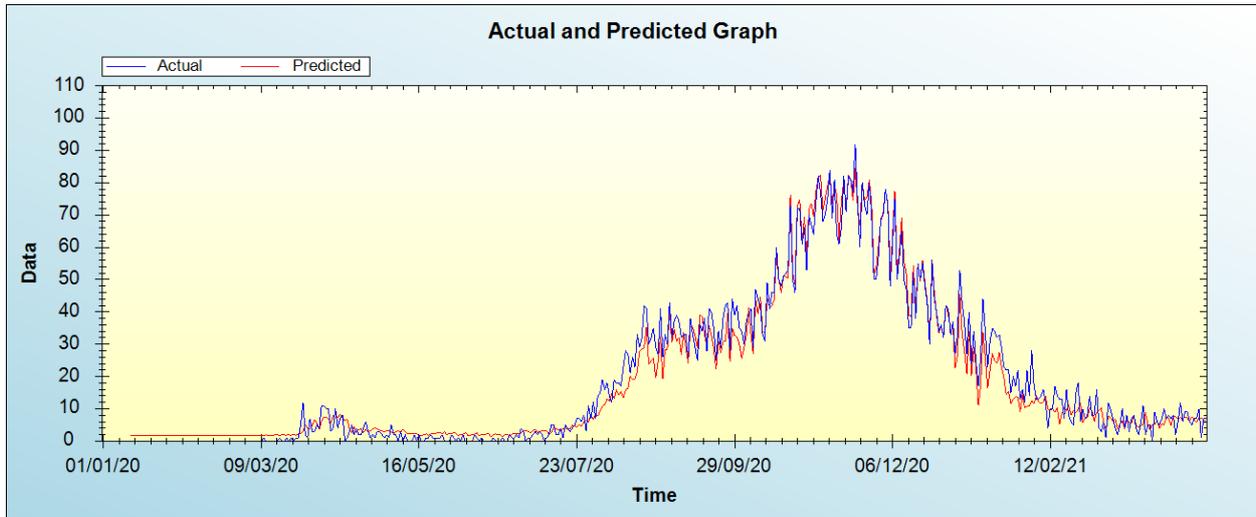
In-sample Forecast for MR

Figure 2: In-sample forecast for the MR series

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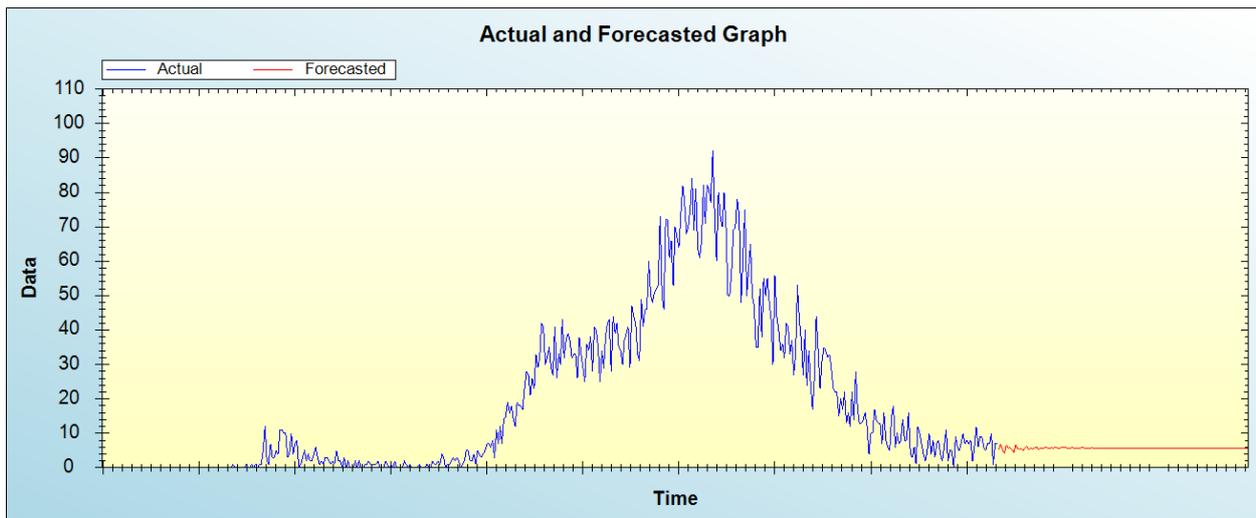

Figure 3: Out-of-sample forecast for MR: actual and forecasted graph

Out-of-Sample Forecast for MR: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Projected COVID-19 deaths
21/04/21	5.3947
22/04/21	6.9148
23/04/21	5.1088
24/04/21	4.1756
25/04/21	6.7057
26/04/21	5.7769
27/04/21	5.8406
28/04/21	5.2930
29/04/21	4.4432
30/04/21	6.6172
01/05/21	5.6518
02/05/21	5.3535
03/05/21	5.6431
04/05/21	4.9880

05/05/21	5.7801
06/05/21	6.1821
07/05/21	5.2864
08/05/21	5.5929
09/05/21	5.4512
10/05/21	5.6864
11/05/21	6.0740
12/05/21	5.4743
13/05/21	5.5825
14/05/21	5.7191
15/05/21	5.6758
16/05/21	5.9740
17/05/21	5.7108
18/05/21	5.5484
19/05/21	5.8193
20/05/21	5.7638
21/05/21	5.8613
22/05/21	5.7995
23/05/21	5.6341
24/05/21	5.8108
25/05/21	5.8295
26/05/21	5.8052
27/05/21	5.8210
28/05/21	5.7034
29/05/21	5.7820
30/05/21	5.8559
31/05/21	5.7903
01/06/21	5.8022
02/06/21	5.7571
03/06/21	5.7700
04/06/21	5.8398
05/06/21	5.7953
06/06/21	5.7807
07/06/21	5.7795
08/06/21	5.7713
09/06/21	5.8170
10/06/21	5.7994
11/06/21	5.7702
12/06/21	5.7827
13/06/21	5.7781
14/06/21	5.7970
15/06/21	5.7973
16/06/21	5.7705
17/06/21	5.7787
18/06/21	5.7834
19/06/21	5.7866
20/06/21	5.7913
21/06/21	5.7741
22/06/21	5.7753
23/06/21	5.7848
24/06/21	5.7831
25/06/21	5.7854
26/06/21	5.7777
27/06/21	5.7749
28/06/21	5.7836
29/06/21	5.7828
30/06/21	5.7817
01/07/21	5.7795
02/07/21	5.7764
03/07/21	5.7820
04/07/21	5.7830
05/07/21	5.7803
06/07/21	5.7799
07/07/21	5.7784

08/07/21	5.7810
09/07/21	5.7829
10/07/21	5.7803
11/07/21	5.7799
12/07/21	5.7799
13/07/21	5.7808
14/07/21	5.7823
15/07/21	5.7808
16/07/21	5.7800
17/07/21	5.7806
18/07/21	5.7809
19/07/21	5.7818
20/07/21	5.7811
21/07/21	5.7802
22/07/21	5.7809
23/07/21	5.7812
24/07/21	5.7814
25/07/21	5.7812
26/07/21	5.7805
27/07/21	5.7809
28/07/21	5.7813
29/07/21	5.7813
30/07/21	5.7812
31/07/21	5.7808
01/08/21	5.7809
02/08/21	5.7813
03/08/21	5.7812
04/08/21	5.7811
05/08/21	5.7809
06/08/21	5.7810
07/08/21	5.7812
08/08/21	5.7812
09/08/21	5.7811
10/08/21	5.7810
11/08/21	5.7810
12/08/21	5.7812
13/08/21	5.7812
14/08/21	5.7810
15/08/21	5.7810
16/08/21	5.7810
17/08/21	5.7811
18/08/21	5.7811
19/08/21	5.7810
20/08/21	5.7810
21/08/21	5.7811
22/08/21	5.7811
23/08/21	5.7811
24/08/21	5.7811
25/08/21	5.7810
26/08/21	5.7811
27/08/21	5.7811
28/08/21	5.7811
29/08/21	5.7811
30/08/21	5.7810
31/08/21	5.7811

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 Morocco are likely to be less than 10 deaths over the out-of-sample period.

V. CONCLUSION AND POLICY RECOMMENDATIONS

Machine learning techniques are prominent in infectious disease modeling because they can model complex and nonlinear data. They have been proven to be superior to traditional statistical methods due to their high predictive accuracy. In this paper we apply the artificial neural network approach to predict daily COVID-19 mortality in Morocco. The ANN model predictions suggest that daily COVID-19 deaths in Morocco are likely to be less than 10 deaths over the out-of-sample period. Therefore the Moroccan government must enforce adherence to WHO guidelines and scale up COVID-19 vaccination.

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