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Forecasting Daily Covid-19 Deaths in Spain Using Artificial Neural Networks

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***Abstract* - In this research paper, the ANN approach was applied to analyze daily COVID-19 deaths in Spain. 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 Spain. The applied ANN (12, 12, 1) model projections indicate that Spain may record no COVID-19 deaths starting from 13 January 2021 till the end of the out-of-sample period. Therefore the government is encouraged to continue applying WHO guidelines on prevention and control of COVID-19 including mass vaccination in order to achieve herd immunity.**

Keywords: ANN, Forecasting, COVID-19.

I. INTRODUCTION

Artificial neural networks (ANNs) are electronic models based on the structure and function of brain (Kishan, 1997). They are increasing getting attention from many researchers in various fields such as engineering, finance and public health (Weng et al, 2017). They have been found to be advantageous as they are capable of modeling nonlinear and complex data which cannot be analyzed by traditional statistical models such as the Box-Jenkins ARIMA models (Nyoni et al, 2020; Zhao et al, 2020). ANNs are useful in pattern recognition, classification, prediction and process control (Hector et al, 2002). ANNs are data driven and self-adaptive in nature (Zhang, 2003). It is not necessary to specify a particular model form or to make an assumption about the statistical distribution of the data. The derived model is adaptively formed based on the features presented from the data. The most widely used ANNs in time series forecasting are the multilayer perceptrons (MLP) which are single hidden layer feed forward networks (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). The model is made of 3 layers of neurons namely the input, hidden and output layers connected by acyclic links called connection weights. In this paper we applied the ANN approach to model and forecast daily COVID-19 deaths in Spain. The results of the study are envisioned to highlight the future trends of COVID-19 mortality in Spain and facilitate the assessment of the impact of COVID-19 prevention and control measures including the vaccination programme.

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 Spain 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	C
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	0.096738
MSE	36215.823201
MAE	108.160719

Residual Analysis for the Applied Model

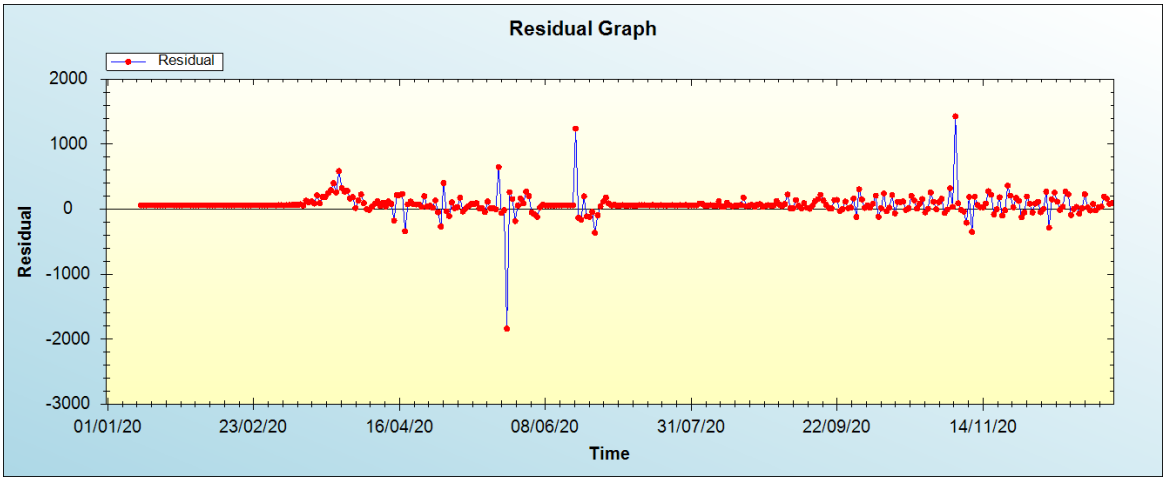

Figure 1: Residual analysis

In-sample Forecast for C

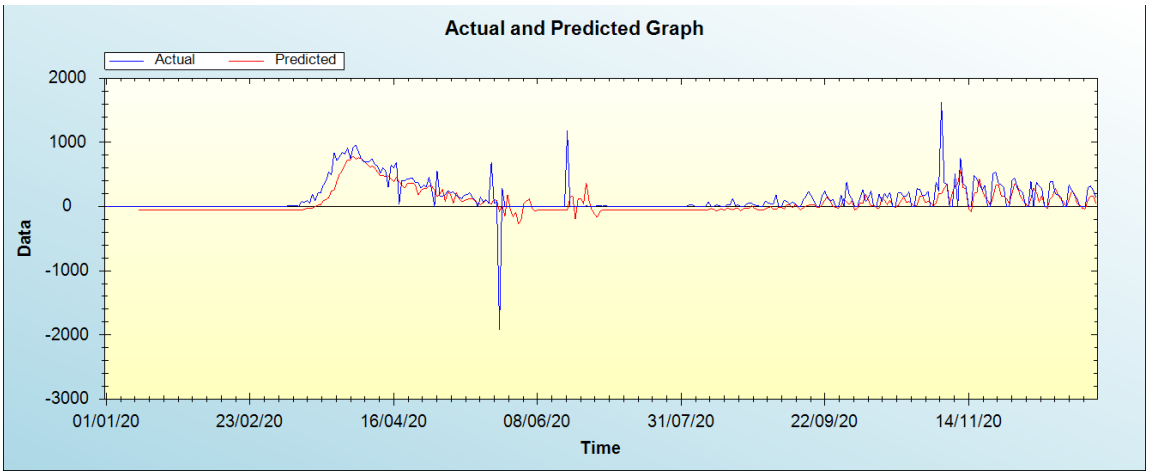

Figure 2: In-sample forecast for the C series

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

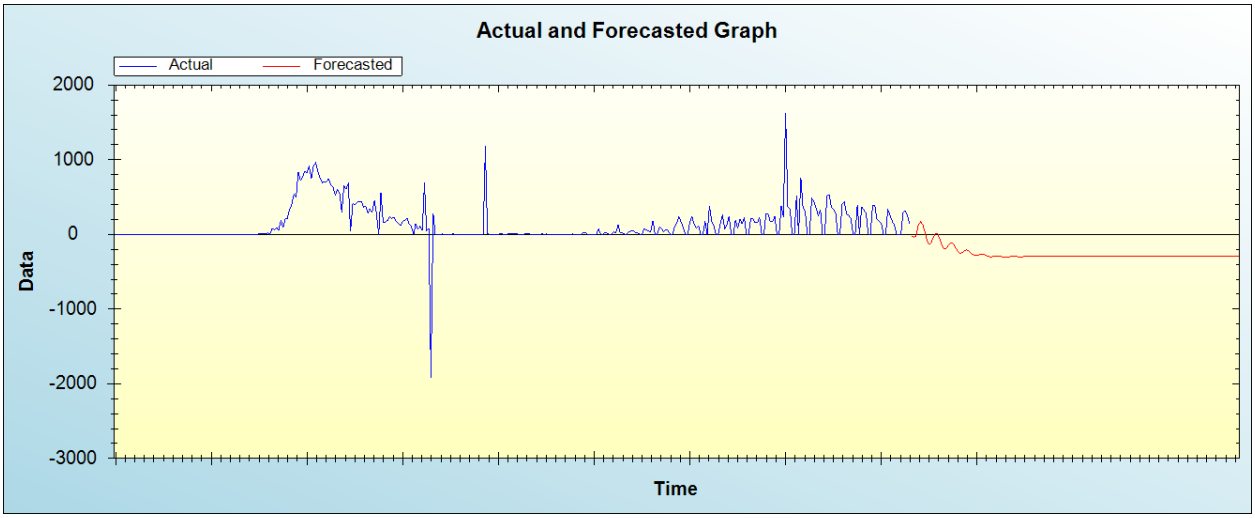

Figure 3: Out-of-sample forecast for C: actual and forecasted graph

Out-of-Sample Forecast for C: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Date	Forecasts
04/01/21	120.8554
05/01/21	170.3441
06/01/21	136.5081
07/01/21	36.3348
08/01/21	-87.2949
09/01/21	-130.0386
10/01/21	-105.5508
11/01/21	-27.5550
12/01/21	19.8351
13/01/21	0.7525

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 Spain may record no COVID-19 deaths starting from 13 January 2021 till the end of the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Machine learning is gaining popularity in time series forecasting problems and is a useful tool in public health surveillance. Several algorithms have been applied and reliable results have been obtained. ANN approach was applied in this paper to model and predict COVID-19 mortality in Spain. Available COVID-19 forecasting models for Spain are basically Box-Jenkins models (Nyoni et al, 2020), for example; Ahmar & Val (2020) and Monllor et al. (2020) and yet these models are well known for poorly performing when it comes to analyzing non-linear complex data sets such as COVID-19 data (Nyoni et al, 2020). In this piece of work the ANN (12, 12, 1) model predictions suggest that Spain is likely to record around zero COVID-19 deaths from Jan 1, 2021 to May 31, 2021. Therefore the government is encouraged to speed up COVID-19 vaccination amongst other control measures.

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