

PREDICTION OF DAILY NEW COVID-19 CASES IN PORTUGAL USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

In this research article, the ANN approach was applied to analyze daily new COVID-19 infections in Portugal. The employed data covers the period 2 March 2020 to 31 October 2020 and the out-of-sample period ranges over the period November 2020 to April 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting daily new COVID-19 infections. The results of the study indicate that the daily new COVID-19 cases are projected to be constant around 4814 cases/day until 30 April 2021. The study recommends that the Portuguese Government should continue enforcing WHO guidelines on prevention and control of the novel coronavirus as study findings suggests that the epidemic is not yet over.

Keywords: - ANN, COVID-19, Forecasting

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a global pandemic that has been affecting Portugal since the time she reported her first case on the 2nd of March 2020 (Pais & Taveira, 2020). WHO declared Europe as the new epicenter of COVID-19 on 13th March, 2020 and most European countries were facing rapid growth of the number of cases (WHO, 2020). Portugal is divided into seven regions according to Nomenclature of Territorial Units for Statistics (NUTII) and these are then subdivided into 308 municipalities. The Norte region carries a substantial burden of the disease in terms of absolute numbers of confirmed cases and deaths due to COVID-19. As of 3 June 2020 the region accounted for 50,5% of the total confirmed cases and 55% of the total number of deaths (Shaaban et al, 2020; WHO, 2011). Portugal has been praised for responding well to the epidemic (Gomes & Carvalho, 2020). The government responded early to the pandemic and several control measures were put into place which include lockdown, social distancing, regular hand washing with soap and water, or use of alcohol-based hand sanitizers and wearing face masks. The Portuguese people complied quickly to measures reducing their overall mobility by 80% (Peixoto et al, 2020). By 3 June, 2020 33,261 people were infected with COVID-19 with 1,447 deaths (Shaaban et al, 2020). The epidemic had serious consequences on the economy and health delivery system. Since it was expected that the global economic meltdown was inevitable the government had to put measures in order to adjust to the new situation by cutting public expenditure and strict fiscal cuts (Karanikolos et al, 2020). The emergency of COVID-19 pandemic has resulted in the increased demand for healthcare

resources such as general hospital beds, ICU beds, Ventilators, sanitizers, face masks, health care workers, financial resources and obviously the demand for an effective vaccine to control the pandemic. However, this pandemic disrupted several economic activities which are a source of livelihood for many people across the globe. The purpose of this study is to forecast daily new COVID-19 cases in Portugal over the period November 1,2020 to April 30,2021 and the findings of this research will guide policy formulation and National response to the epidemic.

LITERATURE REVIEW

Table 1: Literature Review

Author(s)/year	Study period	Method	Major findings
Pais &Taveira (2020)	2March 2020 to 19 August 2020.	A mathematical model was developed based on 2 differential equations which reflected the infected cases(I) and Susceptible cases(S).	The model showed that the population compliance of the government-imposed measures (GIM) was gradual between 30-75% contributing a significant reduction on the infection peak.
Teles.P(2020).	15February 2020 to 15 April 2020.	SIR model	The estimated epidemic peak is about 19000 active cases, hospitalized cases would reach a peak of about 1,250cases.200-300 in ICU units which is manageable as the NHS has about 1140 ventilators.
Silva etal (2020)	2March 2020 to 29 July 2020	SAIRP model	About 67,5% of the population was protected by the COVID-19 confinement policies during the 2emergency states.
Milhinhos &Costa (2020).	2March ,2020 to 19 April,2020	Nonlinear logistic model, Log-Gaussian distribution biphasic asymmetric response	The number of new COVID-19 cases is expected grow in the forth coming months

		model	
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METHOD

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Portugal. The study particularly applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function.

Data Issues

This study is based on daily new COVID-19 cases (referred to as P series in this study) for all age groups in Portugal. The data covers the period 2march 2020 to 31October 2020 while the out-of-sample forecast covers the period November 2020 to April 2021. All the data employed in this research paper was gathered from Johns Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 2: Descriptive statistics

Mean	Median	Minimum	Maximum
580.33	336.50	0.00000	4656.0
Std. Dev.	C.V.	Skewness	Ex. Kurtosis
748.70	1.2901	3.1457	10.667
5% Perc.	95% Perc.	IQ range	Missing obs.
26.750	2373.5	404.25	0

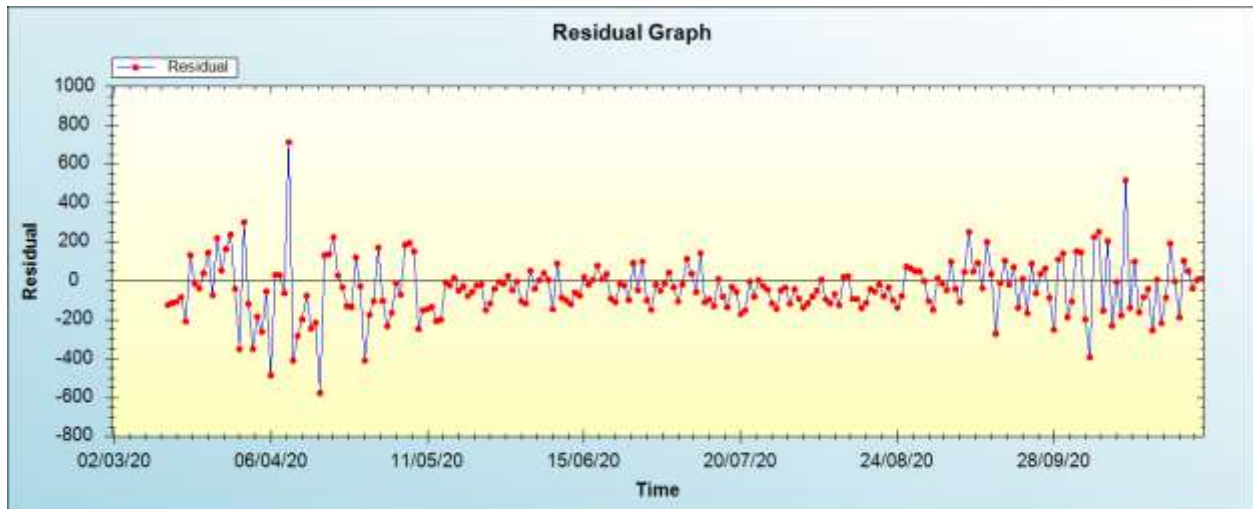
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN PORTUGAL

Table 3: ANN model summary

Variable	P
Observations	232 (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	0.057834
MSE	22379.378183
MAE	109.692936

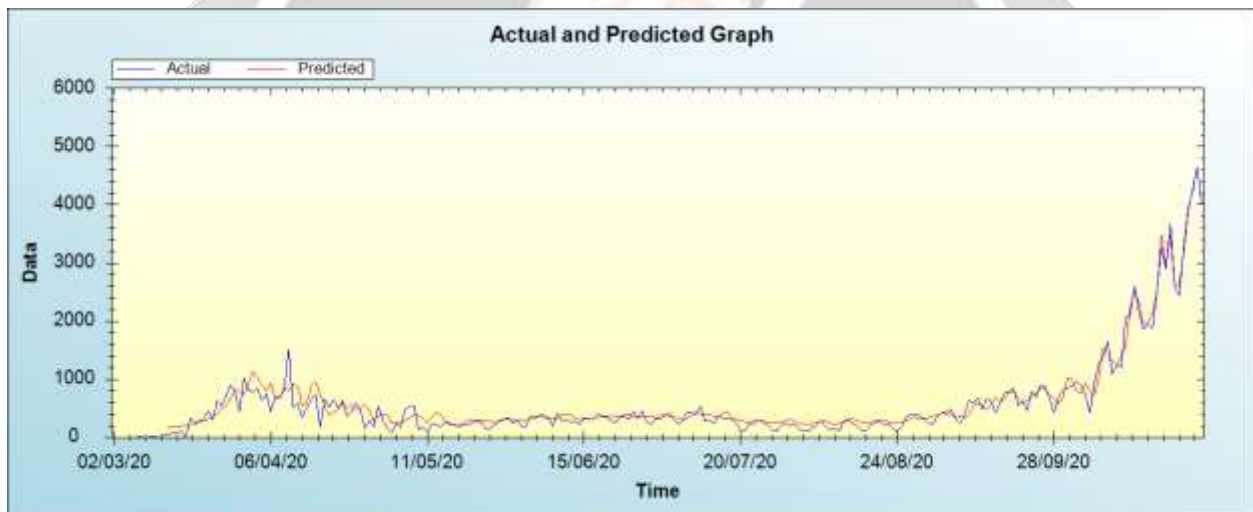
Residual Analysis for the ANN model

Figure 1: Residual analysis



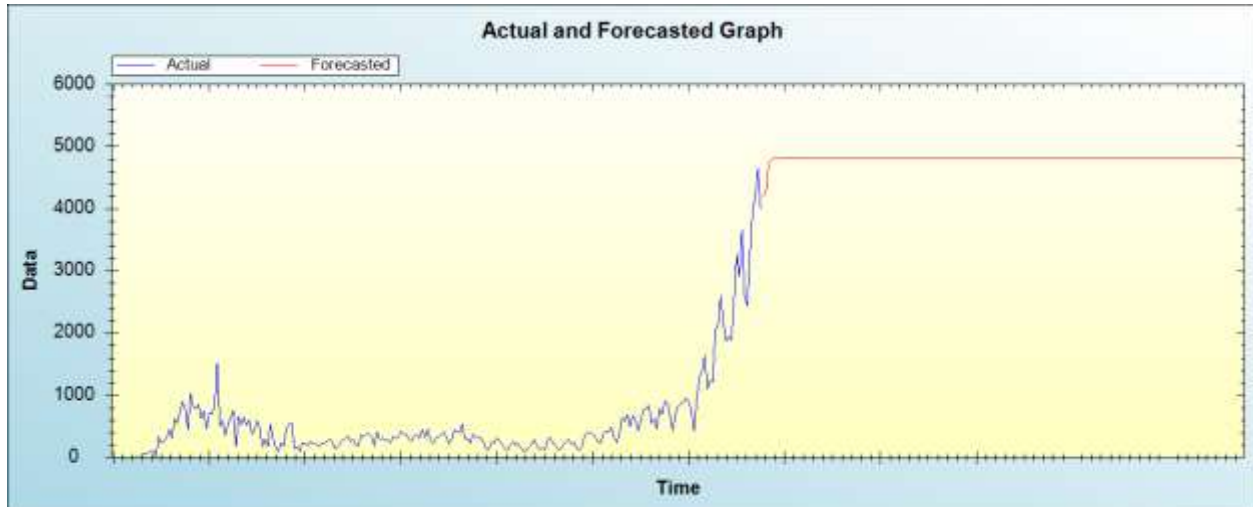
In-sample Forecast for P

Figure 2: In-sample forecast for the P series



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

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



Out-of-Sample Forecast for P: Forecasts only

Table 4: Forecasts

Day/Month/year	Forecasted daily new COVID-19 cases
01/11/20	4196.2772
02/11/20	4266.6299
03/11/20	4726.0276
04/11/20	4778.1187
05/11/20	4828.3897
06/11/20	4799.2201
07/11/20	4813.6550
08/11/20	4802.6915
09/11/20	4818.7108
10/11/20	4807.0365
11/11/20	4828.5984
12/11/20	4820.8098
13/11/20	4823.0118
14/11/20	4812.9350
15/11/20	4815.1870

16/11/20	4813.6804
17/11/20	4815.0763
18/11/20	4814.1245
19/11/20	4814.9518
20/11/20	4814.2273
21/11/20	4814.7983
22/11/20	4814.0218
23/11/20	4814.4371
24/11/20	4814.2510
25/11/20	4814.5512
26/11/20	4814.4031
27/11/20	4814.4835
28/11/20	4814.4186
29/11/20	4814.4696
30/11/20	4814.4248
01/12/20	4814.4602
02/12/20	4814.4330
03/12/20	4814.4625
04/12/20	4814.4431
05/12/20	4814.4537
06/12/20	4814.4430
07/12/20	4814.4501
08/12/20	4814.4458
09/12/20	4814.4490
10/12/20	4814.4465
11/12/20	4814.4486

12/12/20	4814.4469
13/12/20	4814.4482
14/12/20	4814.4470
15/12/20	4814.4479
16/12/20	4814.4474
17/12/20	4814.4478
18/12/20	4814.4475
19/12/20	4814.4477
20/12/20	4814.4475
21/12/20	4814.4477
22/12/20	4814.4476
23/12/20	4814.4476
24/12/20	4814.4476
25/12/20	4814.4476
26/12/20	4814.4476
27/12/20	4814.4476
28/12/20	4814.4476
29/12/20	4814.4476
30/12/20	4814.4476
31/12/20	4814.4476
01/01/21	4814.4476
02/01/21	4814.4476
03/01/21	4814.4476
04/01/21	4814.4476
05/01/21	4814.4476
06/01/21	4814.4476

A large, semi-transparent watermark of the IJARIE logo is centered over the table. The logo features a stylized globe with a white swoosh and the acronym 'IJARIE' in bold, white, sans-serif font below it.

07/01/21	4814.4476
08/01/21	4814.4476
09/01/21	4814.4476
10/01/21	4814.4476
11/01/21	4814.4476
12/01/21	4814.4476
13/01/21	4814.4476
14/01/21	4814.4476
15/01/21	4814.4476
16/01/21	4814.4476
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30/01/21	4814.4476
31/01/21	4814.4476
01/02/21	4814.4476

02/02/21	4814.4476
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28/02/21	4814.4476
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24/03/21	4814.4476
25/03/21	4814.4476

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26/03/21	4814.4476
27/03/21	4814.4476
28/03/21	4814.4476
29/03/21	4814.4476
30/03/21	4814.4476
31/03/21	4814.4476
01/04/21	4814.4476
02/04/21	4814.4476
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26/04/21	4814.4476
27/04/21	4814.4476
28/04/21	4814.4476
29/04/21	4814.4476
30/04/21	4814.4476

Figure 1 shows that over the study period the minimum and maximum number of daily new COVID-19 cases are 0 and 4656 respectively. Skewness and kurtosis values indicate that the data is not normally distributed. The ANN (12,12,1) model simulates the observed data very well. The residual graph and model evaluation criteria indicate that the applied ANN model is adequate, stable and suitable for forecasting daily new COVID-19 cases. The COVID-19 daily new cases are projected to be generally constant at around 4814 cases per day until 30 April 2021.

CONCLUSION & RECOMMENDATIONS

Portugal has made tremendous effort in trying to contain the spread of COVID-19 among communities, however projections from this study indicate the daily new cases of COVID-19 will generally be constant around 4814 cases from November 2020 to 30 April 2021. The study recommends that the Portuguese government should continue enforcing WHO guidelines on prevention and control of COVID-19 as this piece of work is suggesting that the epidemic is not yet over.

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