

FORECASTING COVID-19 CASES IN PAKISTAN USING ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Pakistan continues to be severely affected by COVID-19 and the situation is even worse given the fact that the country already has a fragile healthcare system alongside perennial economic and political instability. In this research article, the ANN approach was applied to forecast the future trend of COVID case volumes in Pakistan. The employed data covers the period February 25, 2020 to October 31, 2020 while 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 very stable and quite acceptable in forecasting COVID-19 infections in the country. The study suggests that the number of daily new COVID-19 cases is likely to follow a downwards trend over the out-of sample period, characterized by an equilibrium level of approximately 227 cases per day. The government of Pakistan is encouraged to continue enforcing WHO guidelines on the prevention and control of the pandemic and also people in the country are advised to continue behaving in a responsible manner with regards to face-mask wearing and following all sanitary rules put forward by WHO.

Keywords: - ANN, COVID-19, Forecasting

INTRODUCTION

A viral infection, now known as COVID-19, believed to have been contracted from wild animals; was initially identified in the Wuhan city of China (Paules *et al.*, 2020). This disease has affected millions upon millions of people around the globe. The World Health Organization (WHO) declared it as a pandemic on March 11 (WHO, 2020). Causing a respiratory illness, the COVID-19 scourge has a number of symptoms but the most common ones include fever and cough (BioGaia, 2020). COVID-19 has frustrated the whole world due to the fact that it is highly contagious (Fong *et al.*, 2020). The fatality rate is higher among the elderly, especially those aged above 60 years (WHO, 2020). The first 2 cases of COVID-19 in Pakistan were reported on the 25th of February 2020 (MNHSRC, 2020). After that, an increase in COVID-19 cases was observed in Pakistan (Syed & Sibgatullah, 2020). In order to prevent the pandemic from worsening in Pakistan, we attempt to model and forecast the disease progression using Artificial Neural Networks (ANNs). The results of the study will be used for planning ahead and strengthening existing COVID-19 control and prevention strategies.

LITERATURE REVIEW

There is vast literature on the predicting modelling of COVID-19 cases in Pakistan. Below, we present a review of selected major studies:

Author/s (Year)	Study Period	Method	Key Results
Yousaf <i>et al.</i> (2020)	February – April	ARIMA model	There was high exponential growth in the number of confirmed cases, deaths and recoveries in Pakistan
Khan <i>et al.</i> (2020)	February – May	VAR model	The maximum number of new daily cases for Pakistan will be 5363 per day on July 3, 2020
Arfan <i>et al.</i> (2020)	February – May	Caputo Power Law model	Strict precautionary measures will slow down the transmission rate of the virus
Aslam <i>et al.</i> (2020)	February – April	ARIMA model	There was high exponential growth in the number of confirmed cases
Waqas <i>et al.</i> (2020)	February – April	SIR model	The outbreak will reach its maximum peak from late May to June 9, 2020, with unrecovered number of infections in the range 20000 – 47000
Qasim <i>et al.</i> (2020)	February – March	SIR model	Number of cases expected to continue rising exponentially
Iftikhar & Rind (2020)	February – August	AR, MA, ARMA, NPAR, and SES models	Confirmed cases are still increasing in the country
Ali <i>et al.</i> (2020)	February – May	SEIR model	Peak will be in mid-September 2020
Chaudhry <i>et al.</i> (2020)	February – April	MA model	COVID-19 cases will go over 35000 by end of May 2020
Dil <i>et al.</i> (2020)	February – March	SEIR model	Pakistan ought to prepare for a surge in COVID-19 cases
Shah <i>et al.</i> (2020)	February – March	SIR model	COVID-19 cases are on the rise
Ahmad & Asad (2020)	February – June	ANN model	COVID-19 cases surging in the country

Source: Literature Review (2020)

METHOD

This paper, in line with previous studies such as Ahmad & Asad (2020); applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in Pakistan. This study specifically 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 H series in this study) for all age groups Pakistan. The data covers the period 25 February 2020 to 31 October 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 John Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 2: Descriptive statistics

Mean	Median	Minimum	Maximum
1335.9	684.50	0.00000	12073.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
1656.4	1.2399	2.3064	7.5270
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	4865.3	1429.0	0

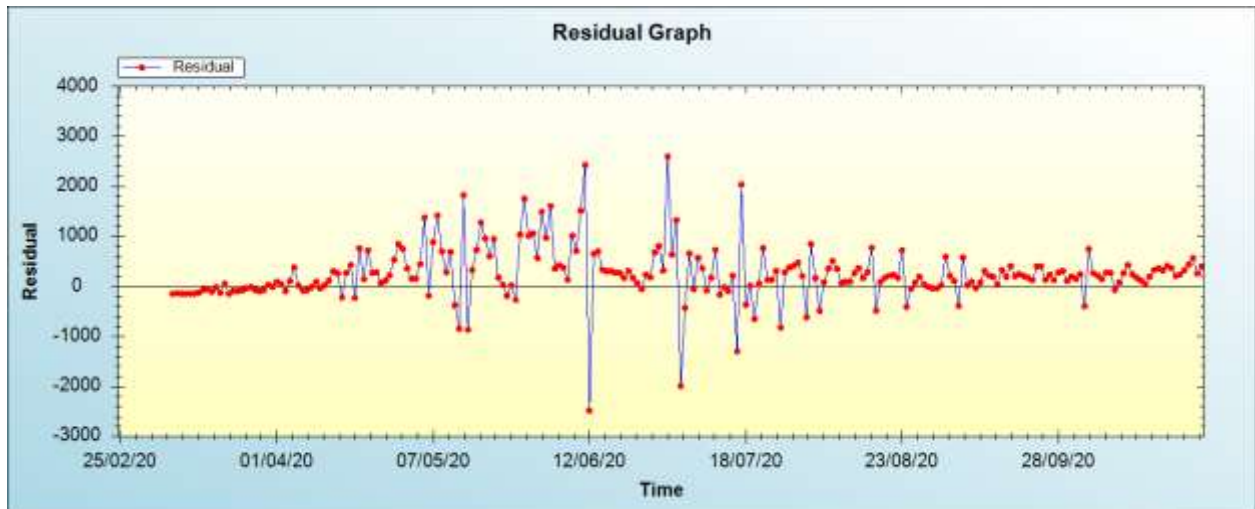
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN PAKISTAN

Table 3: ANN model summary

Variable	H
Observations	238 (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	0.088358
MSE	351215.752367
MAE	391.471626

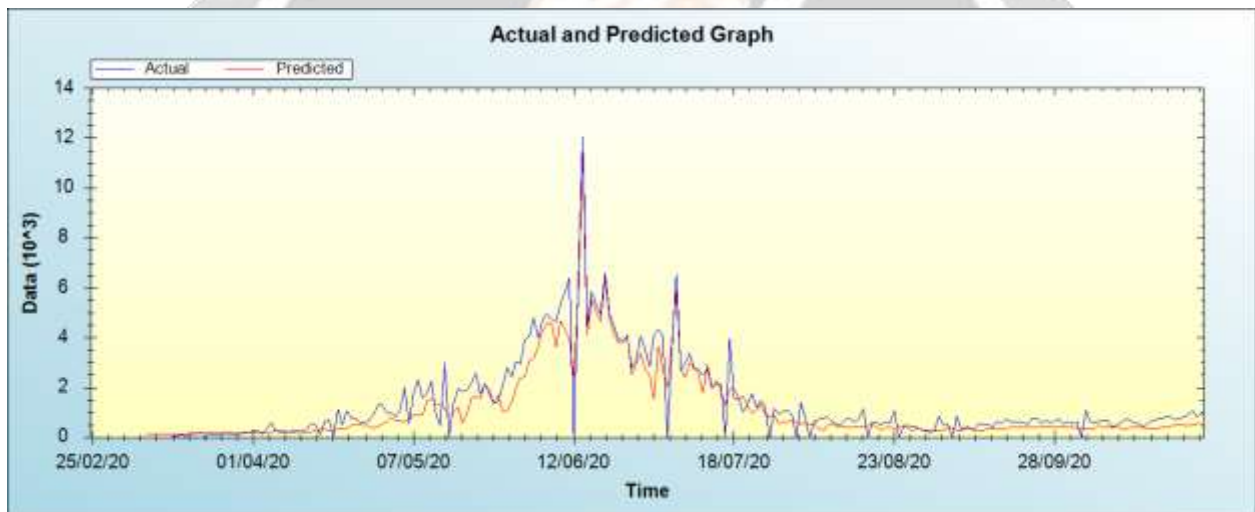
Residual Analysis for the ANN model

Figure 1: Residual analysis



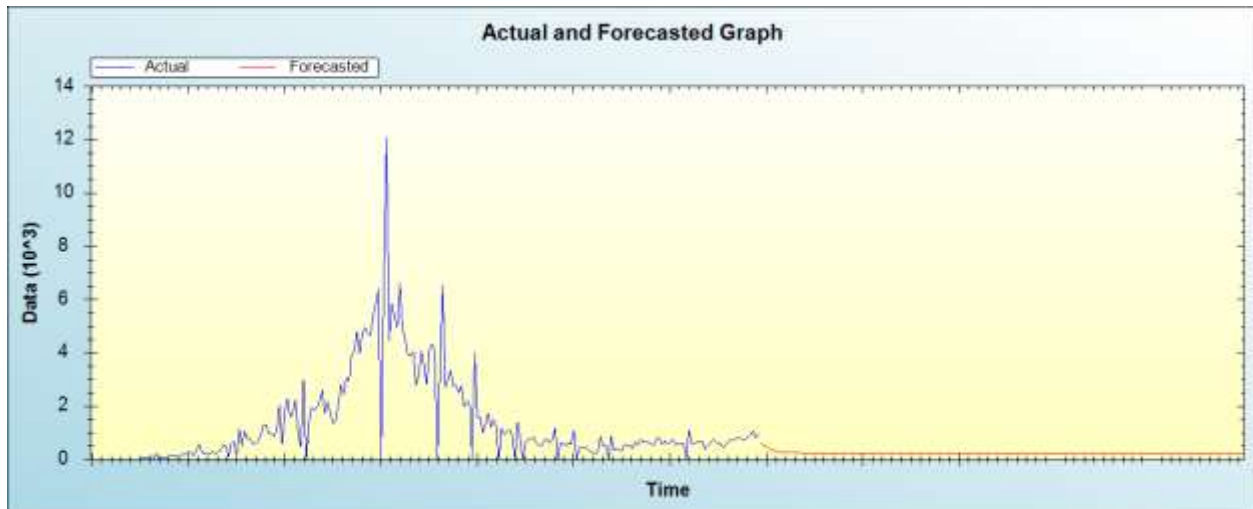
In-sample Forecast for H

Figure 2: In-sample forecast for the H series



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

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



Out-of-Sample Forecast for H: Forecasts only

Table 4: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	583.3785
02/11/20	534.3856
03/11/20	491.3022
04/11/20	398.0429
05/11/20	361.7063
06/11/20	321.6813
07/11/20	299.9271
08/11/20	278.8356
09/11/20	277.9765
10/11/20	287.7143
11/11/20	263.2807
12/11/20	275.0028
13/11/20	257.4611
14/11/20	251.6923
15/11/20	250.0981

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

16/11/20	243.7079
17/11/20	240.2528
18/11/20	236.7398
19/11/20	234.7864
20/11/20	232.3251
21/11/20	231.4598
22/11/20	231.6006
23/11/20	229.8360
24/11/20	230.1310
25/11/20	229.3739
26/11/20	228.8652
27/11/20	228.7547
28/11/20	228.4043
29/11/20	228.1553
30/11/20	227.9033
01/12/20	227.7752
02/12/20	227.5887
03/12/20	227.4833
04/12/20	227.4641
05/12/20	227.3408
06/12/20	227.3241
07/12/20	227.2821
08/12/20	227.2401
09/12/20	227.2252
10/12/20	227.2036
11/12/20	227.1858

12/12/20	227.1676
13/12/20	227.1589
14/12/20	227.1465
15/12/20	227.1371
16/12/20	227.1343
17/12/20	227.1261
18/12/20	227.1229
19/12/20	227.1200
20/12/20	227.1167
21/12/20	227.1150
22/12/20	227.1134
23/12/20	227.1121
24/12/20	227.1107
25/12/20	227.1100
26/12/20	227.1092
27/12/20	227.1085
28/12/20	227.1082
29/12/20	227.1076
30/12/20	227.1073
31/12/20	227.1071
01/01/21	227.1069
02/01/21	227.1067
03/01/21	227.1066
04/01/21	227.1065
05/01/21	227.1064
06/01/21	227.1063

07/01/21	227.1062
08/01/21	227.1062
09/01/21	227.1062
10/01/21	227.1061
11/01/21	227.1061
12/01/21	227.1061
13/01/21	227.1061
14/01/21	227.1060
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30/01/21	227.1060
31/01/21	227.1060
01/02/21	227.1060

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02/02/21	227.1060
03/02/21	227.1060
04/02/21	227.1060
05/02/21	227.1060
06/02/21	227.1060
07/02/21	227.1060
08/02/21	227.1060
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25/02/21	227.1060
26/02/21	227.1060
27/02/21	227.1060

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28/02/21	227.1060
01/03/21	227.1060
02/03/21	227.1060
03/03/21	227.1060
04/03/21	227.1060
05/03/21	227.1060
06/03/21	227.1060
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22/03/21	227.1060
23/03/21	227.1060
24/03/21	227.1060
25/03/21	227.1060

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

26/03/21	227.1060
27/03/21	227.1060
28/03/21	227.1060
29/03/21	227.1060
30/03/21	227.1060
31/03/21	227.1060
01/04/21	227.1060
02/04/21	227.1060
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27/04/21	227.1060
28/04/21	227.1060
29/04/21	227.1060
30/04/21	227.1060

Table 2, which shows the descriptive statistics of the series under consideration indicates that the average number of daily COVID-19 cases in the country has been 1336 over the period under study, while the maximum has been 12073 cases. The summary of the model applied is shown in table 3 and its residual diagnostics are graphically presented in figure 1. Indeed, the residuals are as close to zero as possible, indicating that the model is stable and acceptable for making predictions. Figure 2 shows the in-sample forecasts of our model while figure 3 and table 4 display the out-of-sample forecasts made from the estimated model. We establish that the number of daily COVID-19 cases will continue declining in the country, from the current estimated 583 cases (November 1, 2020) to the equilibrium level of 227 cases per day sometime around December 3, 2020 until April 30, 2020. These results are not consistent with previous studies such as Yousaf *et al.* (2020), Ahmad & Asad (2020), Shah *et al.* (2020), Chaudhry *et al.* (2020), Iftikhar & Rind (2020), Ali *et al.* (2020), Qasim *et al.* (2020), Waqas *et al.* (2020), Aslam *et al.* (2020), Khan *et al.* (2020); largely because of the fact that the government of Pakistan has now implemented the strict measures against COVID-19 and many people in the country are now beginning to adjust to the new normal of face-mask wearing, sanitizing hands and so on., which suggests that the virus is now significantly under control. This is the reason why we see a downwards trajectory of predicted cases.

CONCLUSION & RECOMMENDATIONS

At the moment, COVID-19 is the most frightening outbreak in the world. Everyone is afraid of catching the virus. However, as a matter of fact, a significantly high number of infected patients have already recovered from this disease and many people around the world are beginning to realize that the pandemic is not a death sentence. Even in Pakistan, during the onset of the virus, everyone was extremely afraid of it because the disease was not yet well understood. Today, people in Pakistan have adjusted to the new normal and this could lead to positive changes in terms of controlling the spread of COVID-19 in the country. In this study, an ANN model is applied to model and forecast COVID-19 daily cases in Pakistan. The model suggests that the number of daily new COVID-19 cases is likely to follow a downwards trend over the out-of

sample period, characterized by an equilibrium level of approximately 227 cases per day. The government of Pakistan is encouraged to continue enforcing WHO guidelines on the prevention and control of the pandemic and also people in the country are advised to continue behaving in a responsible manner with regards to face-mask wearing and following all sanitary rules postulated by WHO.

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