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

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ABSTRACT.

Understanding the nature of COVID—19 epidemic in Kuwait is key in order for the government to respond timeously and appropriately to curb the spread of the deadly virus. Many epidemiological Models have been applied especially the famous compartmental models: the SIR and SEIR models. These models are good in the assessment of the transmission rate of the virus, forecasting epidemic peak and final size of the epidemic. However, in this study the artificial neural network is applied because of its good forecast accuracy and reliability of the results. The ANN (12, 12, 1) model with hyperbolic tangent activation function is used and the model evaluation criteria indicate that the model is adequate, stable and suitable for forecasting daily new COVID-19 cases in the State of Kuwait. Our study findings indicate that daily COVID-19 cases will remain high although generally declining. The study recommends that Kuwait should continue enforcing the recommended WHO guidelines on prevention and control of COVID-19 with particular emphasis on regular hand washing with soap, social distancing, wearing face masks, testing &treatment of cases, early isolation and continuous education among communities.

Keywords: - *ANN, COVID-19, Forecasting*

INTRODUCTION

The first cases of COVID-19 in the State of Kuwait were diagnosed in travelers who were placed under immediate institutional quarantine on 24 February 2020(Alkhamis et al, 2020; AlShukry et al, 2020). Mass screening of incoming travelers from countries who had reported the coronavirus outbreaks was done. All COVID-19 suspected cases were transferred to one centre ,Jaber Al-Sabal Hospital where laboratory confirmatory tests were carried out and positive ones were treated appropriately(Almazeedi et al,2020).The COVID-19 infected patients exhibited varying clinical symptoms which included asymptomatic ,acute respiratory distress Syndrome (ARD) and pneumonia symptoms with varying severity (Lai et al,2020).COVID-19 is known to be more severe in elderly patients and in patients with pre-existing chronic medical conditions such as Diabetes Mellitus and heart failure (Yang etal, 2020). Coronaviruses are minute single stranded RNA viruses that belong to a broad family called Coronaviridae (Ayed et al, 2020). These viruses were known to infect animals only. The lack of vaccine has contributed to the spread of this communicable disease. COVID-19 related mortality has been attributed to the virus activated "cytokine storm syndrome." (Ruan et al, 2020). The state of Kuwait has implemented

gradual control measures in an attempt to control the spread of the virus and these included closure of schools, universities, government offices, on-essential businesses, border lockdown, partial curfew and geographic isolation areas experiencing wide community transmission (Al-Shummari et al, 2020). Several mathematical models have been applied to try and understand the dynamics of the COVID-19 outbreak. Infectious disease transmission dynamics models are the most common in literature namely the SIR and SEIR models (Camacho et al, 2020). However, under reporting of COVID -19 cases poses a challenge in understanding the trends of the epidemic. In this study we use the ANN model to forecast daily new COVID-19 cases from November 1, 2020 to 30 April 2021.The findings of this study will enable the State of Kuwait to Implement timeous and appropriate response to the epidemic.

LITERATURE REVIEW

Table 1: Selected Papers

Author(s)/year	Study period	Method	Major Findings
Alkhamis et al (2020)	23 February 2020 to 07 May, 2020	-Time-dependent reproductive numbers model -Multivariate permutation scan statistic (MPSS) model	The pandemic size in Kuwait continues to grow R(t)>2. Indicating significant ongoing spread. Significant spreading and clustering events were detected among migrant workers to their densely populated areas and poor living conditions.
Al-Shammari etal (2020)	25 February 2020 to April 30 ,2020	A deterministic compartmental model for infectious disease with additional compartments was used	Early control measures implemented in Kuwait delayed the intensity of the outbreak but were unsuccessful in reducing R (t) below 1.
Youha et al (2020)	24 February 2020-28 April 2020.	Model discrimination was assessed through the area under the recover operating characteristic curve (AUC) while model calibration was	Successful validation of the laboratory based prognostic scoring system for COVID-19 patients to predict a severe

		assessed through a calibration plot and measures of slope and calibration in the large (CITL)	clinical course.
Alhamli.M. K (2020)	25 February 2020 to 10 June 2020	Modified compartmental epidemic model	Hospitalization rate is predicted to peak on August 27,2020, September 20,2020 and December 21,2020at values141,184;85341; and 16412 respectively. Reproductive number was found to be 2.18.ICU beds estimated to be 16461;9645, and 1788. Deaths estimated to be 29202 ;23973 and 11565 respectively

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 Kuwait. 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 KC series in this study) for all age groups in Kuwait. The data covers the period 24February 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 John Hopkins University (USA).

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 2: Descriptive statistics

Mean	Median	Minimum	Maximum

501.70	590.00	0.00000	1073.0
Std. Dev.	C.V.	Skewness	Ex. kurtosis
304.40	0.60675	-0.42814	-1.0003
5% Perc.	95% Perc.	IQ range	Missing obs.
2.6000	911.40	504.00	0

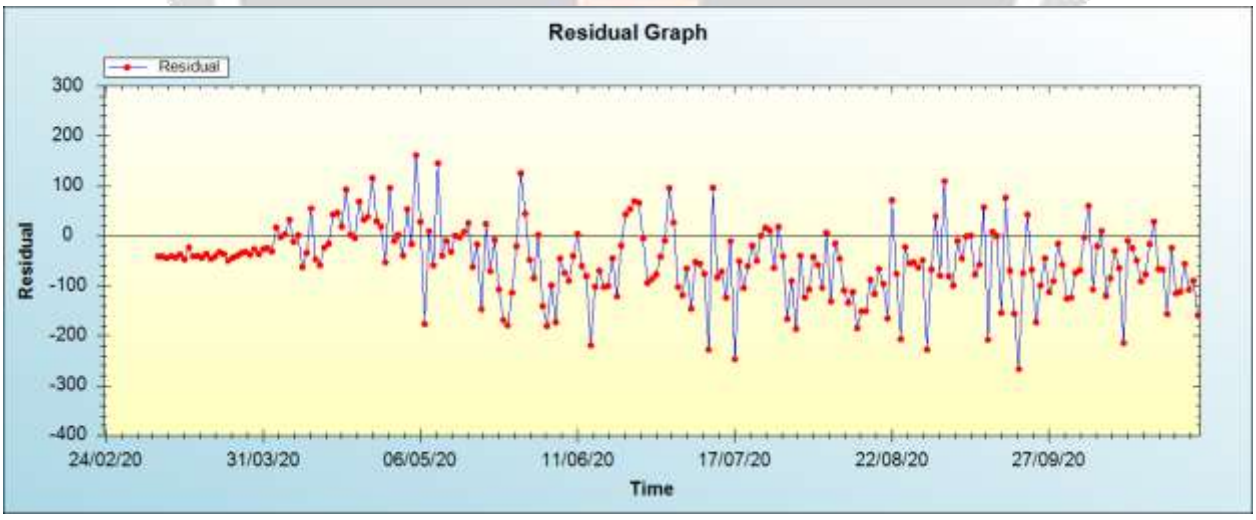
ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN KUWAIT

Table 3: ANN model summary

Variable	KC
Observations	239 (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	0.147193
MSE	7698.940535
MAE	69.127407

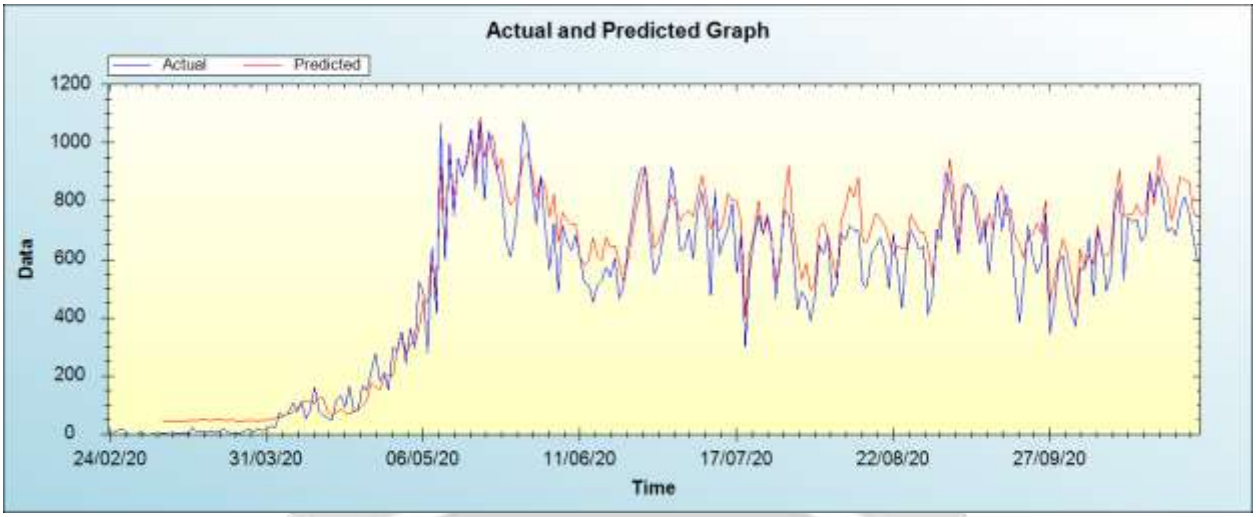
Residual Analysis for the ANN model

Figure 1: Residual analysis



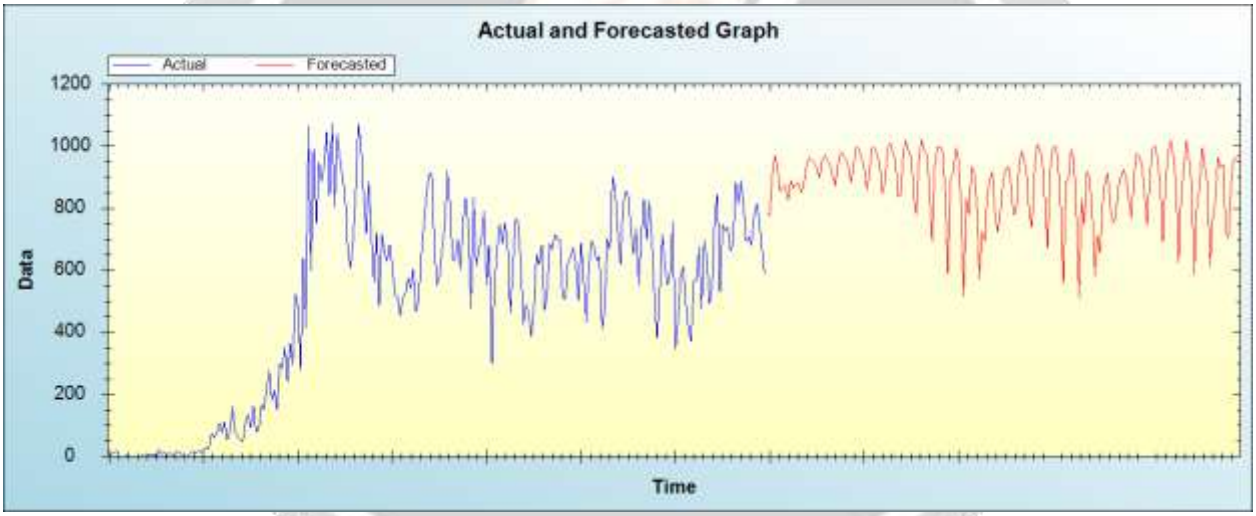
In-sample Forecast for KC

Figure 2: In-sample forecast for the KC series



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

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



Out-of-Sample Forecast for KC: Forecasts only

Table 4: Tabulated out-of-sample forecasts

Day/Month/year	Forecasted daily new COVID-19 cases
01/11/20	785.1538
02/11/20	775.4360
03/11/20	906.9125
04/11/20	971.2981
05/11/20	928.1901

06/11/20	852.5921
07/11/20	870.1942
08/11/20	872.4258
09/11/20	824.5780
10/11/20	888.6579
11/11/20	864.8855
12/11/20	879.4221
13/11/20	879.8309
14/11/20	851.2407
15/11/20	877.3517
16/11/20	936.6212
17/11/20	962.9061
18/11/20	954.8752
19/11/20	948.0521
20/11/20	927.6576
21/11/20	899.3318
22/11/20	952.7928
23/11/20	972.5021
24/11/20	955.2997
25/11/20	939.5907
26/11/20	904.8286
27/11/20	873.5571
28/11/20	936.5793
29/11/20	980.2764
30/11/20	973.6577
01/12/20	962.5208

02/12/20	934.5008
03/12/20	881.8159
04/12/20	940.9032
05/12/20	998.5192
06/12/20	990.1727
07/12/20	965.7909
08/12/20	934.0966
09/12/20	858.1029
10/12/20	913.2589
11/12/20	994.2793
12/12/20	996.8194
13/12/20	971.8064
14/12/20	943.7305
15/12/20	847.7131
16/12/20	886.4851
17/12/20	994.2279
18/12/20	1010.6728
19/12/20	978.2152
20/12/20	952.8278
21/12/20	837.5109
22/12/20	841.7267
23/12/20	986.9969
24/12/20	1018.9408
25/12/20	983.2207
26/12/20	962.1250
27/12/20	835.2261

28/12/20	779.3618
29/12/20	971.9253
30/12/20	1020.3497
31/12/20	989.8910
01/01/21	972.0271
02/01/21	841.2144
03/01/21	692.4230
04/01/21	943.5706
05/01/21	998.2486
06/01/21	998.1768
07/01/21	977.2629
08/01/21	840.9599
09/01/21	587.7914
10/01/21	894.4406
11/01/21	917.8784
12/01/21	994.8558
13/01/21	960.3454
14/01/21	813.5554
15/01/21	517.5776
16/01/21	831.8788
17/01/21	780.6837
18/01/21	936.2715
19/01/21	916.4720
20/01/21	817.5712
21/01/21	572.0898
22/01/21	727.8087

23/01/21	695.6704
24/01/21	849.9316
25/01/21	895.5978
26/01/21	917.2007
27/01/21	771.9382
28/01/21	725.3845
29/01/21	790.0098
30/01/21	888.5364
31/01/21	925.3739
01/02/21	935.3778
02/02/21	878.9205
03/02/21	780.4356
04/02/21	786.8723
05/02/21	929.7061
06/02/21	985.9938
07/02/21	960.1033
08/02/21	912.6668
09/02/21	785.5079
10/02/21	738.5492
11/02/21	928.6301
12/02/21	1004.8108
13/02/21	990.2058
14/02/21	955.1853
15/02/21	821.8638
16/02/21	672.7396
17/02/21	925.0488

18/02/21	994.2377
19/02/21	1002.5186
20/02/21	955.4732
21/02/21	802.2271
22/02/21	556.5776
23/02/21	886.0354
24/02/21	891.9390
25/02/21	992.0803
26/02/21	954.6673
27/02/21	792.7049
28/02/21	510.9512
01/03/21	831.4432
02/03/21	747.9047
03/03/21	919.7101
04/03/21	901.4917
05/03/21	794.5977
06/03/21	582.3481
07/03/21	713.5088
08/03/21	657.2489
09/03/21	816.1367
10/03/21	890.7532
11/03/21	912.8136
12/03/21	796.5036
13/03/21	753.1568
14/03/21	767.7108
15/03/21	869.4875

16/03/21	904.0047
17/03/21	923.3833
18/03/21	899.6918
19/03/21	826.2384
20/03/21	767.9695
21/03/21	910.3088
22/03/21	977.2610
23/03/21	969.5221
24/03/21	937.9583
25/03/21	851.0816
26/03/21	746.4945
27/03/21	902.2736
28/03/21	993.2258
29/03/21	1003.1431
30/03/21	959.6500
31/03/21	877.4962
01/04/21	692.0917
02/04/21	882.8400
03/04/21	982.9398
04/04/21	1019.5029
05/04/21	966.3782
06/04/21	878.4594
07/04/21	626.7877
08/04/21	848.3156
09/04/21	933.1892
10/04/21	1020.5740

11/04/21	956.9383
12/04/21	874.0353
13/04/21	586.3577
14/04/21	817.7766
15/04/21	861.4991
16/04/21	997.6208
17/04/21	934.2657
18/04/21	884.1193
19/04/21	612.8312
20/04/21	761.4001
21/04/21	822.9143
22/04/21	964.2293
23/04/21	930.1842
24/04/21	942.3939
25/04/21	721.4564
26/04/21	703.3782
27/04/21	873.1677
28/04/21	959.8058
29/04/21	963.6376
30/04/21	974.1793

Figure 4: Graphical presentation of out-of-sample forecasts

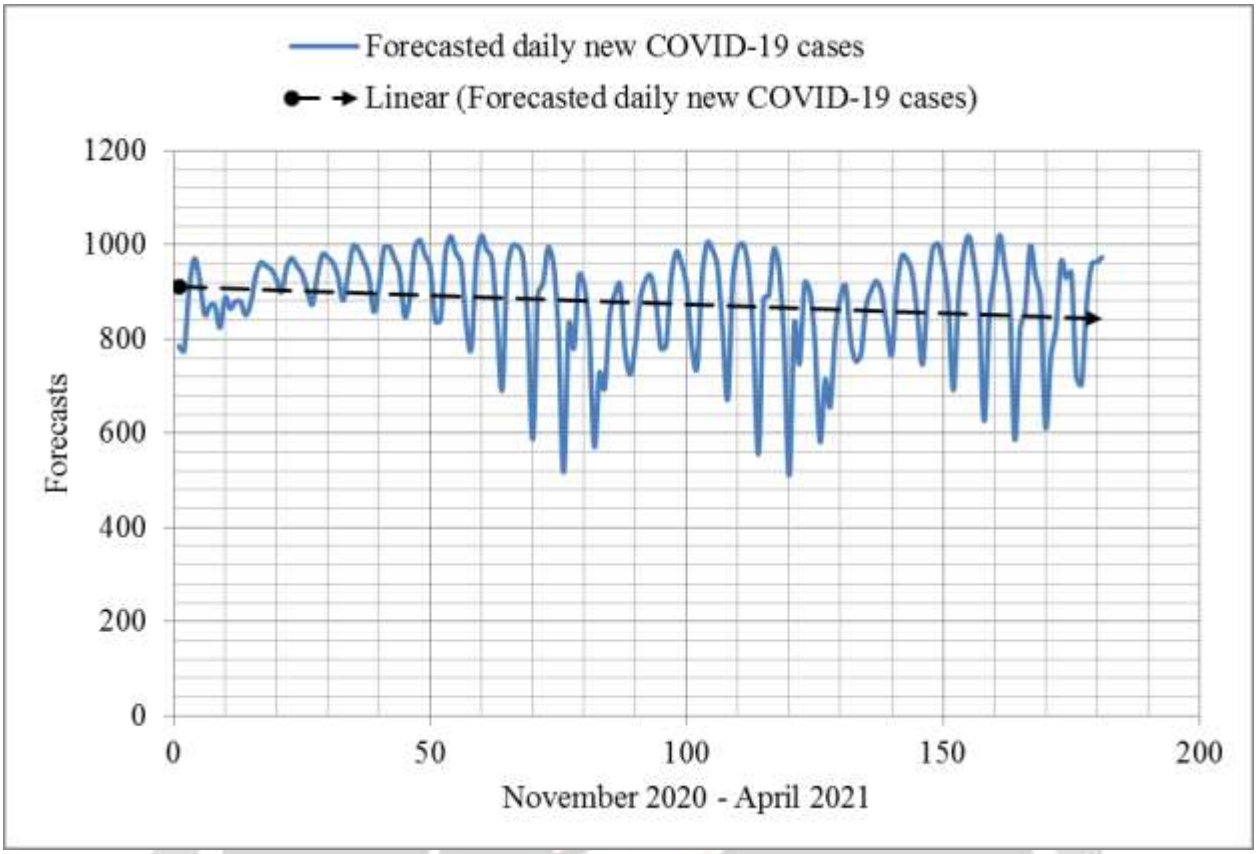


Figure 1 shows that over the study period, the minimum and maximum number of daily new cases are 0 and 1073 respectively. The average daily new cases are 501. The ANN(12,12,1) model simulates the observed data very well as shown in Figure 3. The residual graph indicates that the model is adequate and suitable for forecasting daily new COVID-19cases. The out of sample forecast show that daily COVID-19 cases will remain high although generally declining.

CONCLUSION & RECOMMENDATIONS

The state of Kuwait continues to face the COVID-19 epidemic and there is evidence that the virus is rapidly spreading and pandemic size continues to grow, R(t) greater or equal to 2 and clusters of affected people include migrant workers due to their densely populated and poor living conditions(Alkhamis et al, 2020). Study findings by Alhamli.M.K(2020) indicates that coronavirus epidemic is associated with high hospitalization rates which will result in the health system failing to cope with increasing demand for hospital beds. Furthermore, many people are projected to died from the disease as suggested by Alhamali.M. K (2020). The state of Kuwait should continue enforcing the WHO guidelines on prevention and control of COVID-19 with particular attention to regular hand washing with soap, social distancing, wearing face mask, testing & treatment of cases, early isolation and continuous health education among communities.

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