

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

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## ABSTRACT

*Modeling and forecasting of new cases of COVID-19 has been done by many researchers around the globe. The models that have been found to be successful and reliable include logistic, Gompertz, Artificial neural networks and Ensemble neural networks. The dynamics of viral transmission and assessment of control measures has been done through the application of the famous compartmental models. However, in this paper the Artificial neural network ANN (12,12,1) model which uses the hyperbolic tangent activation function is applied. The model evaluation criteria (error, MSE, MAE) indicate that the model is adequate and suitable for forecasting daily new COVID-19 cases in Mexico. The research findings indicate that the projected daily new coronavirus cases will be constant at around 5000 cases until 30 April, 2021. If an effective vaccine is introduced in the out-of sample period daily new cases are expected to drop. The study recommends continuous enforcement of WHO guidelines on prevention and control of COVID-19 in order to avoid another wave of new infections in Mexico.*

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

## INTRODUCTION

In December 2019, a novel coronavirus disease emerged in Wuhan, China and was described as a viral infection with a high level of transmission (Rodriguez et al, 2020). The causative agent is a new beta coronavirus related to the Middle East Respiratory Syndrome (MERS) and the Severe Acute Respiratory syndrome Virus (SARS-COV) (Leon et al, 2020; Gorbalyena et al 2020; Cui et al, 2020). Mexico had its first confirmed cases of COVID-19 on February 27, 2020 in travelers who were returning from Italy and were destined to Sinaloa and Mexico City respectively (Castillo et al, 2020). The Mexican government had to respond to the deadly virus which was spreading rapidly in the community by implementing measures such as social distancing, suspension of all non-essential activities of public, private and social sectors (Castillo et al, 2020). The global effects of the pandemic are many and they vary from country to country but the common ones include psychological distress, economic losses and negative impacts on daily activities (Zowalaty & Jarhult, 2020). Several prediction models have been applied by different researchers to predict the number of COVID-19 infected cases in China such as the Gompertz, logistic regression and Artificial neural networks (Jia et al, 2020). Despite the implementation of several public policies, the evolution of the epidemic in Mexico has motivated scientific research related to the estimation of the number of COVID-19 cases and this is critical

due to the need to anticipate sufficient infrastructure and specialized materials that are needed to deal with the epidemic (Pacheco et al, 2020). This piece of work is such study which will forecast daily new COVID-19 cases from November 2020 to April 2021. Research findings will stimulate an appropriate evidenced based response to the epidemic in Mexico.

## LITERATURE REVIEW

Table 1: Selected Papers

Author(s)/year	Study period	Method	Major findings
Zegarra et al (2020)	17 February 2020 to 23 March 2020	Modified SEIR model	Epidemic peak is likely to be between May and early June 2020 under a scenario of high Sanitary Emergency Measures (SEM).
Melin et al (2020)	Day 1 to day 109 Day 1 being 17 February 2020.	Ensemble neural networks	Ensemble neural networks perform better than the traditional neural networks in forecasting problems
Cibrian et al (2020)	28 February 2020 to 5 April 2020.	Richards Model	The model under estimated the true nature of the number of COVID-19 cases
Castillo et al (2020)	27 February 2020 to 29 April 2020	Modified SEIR model	COVID-19 mitigation measures have managed to flatten the curve moderately, thus shifting the peak newly infected cases to the right to a date around June 1, 2020.
Leon et al (2020)	12 March 2020 to 14 April 2020.	SEIARD model	The epidemic peak in Mexico will be around 2 May 2020.
Lirar A.V(2020)	27 February 2020 to 31 March 2020	Time dependent Markov Chain Model, Modified SIR model	The COVID-19 has a slow infective rate and a tendency to spread in every state

			in Mexico.
Rodriguez et al (2020).	27 February 2020 to 8May 2020.	ANN, Gompertz and Logistic model	There was a good fit between the observed data and those obtained by the Gompertz, logistic and ANN models with R squared of 0.9998,0.9996 and 0.9999 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 Mexico. This 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 MC series in this study) for all age groups in Mexico. The data covers the period 28February 2020 to 30 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 Johns Hopkins University (USA).

**FINDINGS OF THE STUDY**

**DESCRIPTIVE STATISTICS**

Table 2: Descriptive statistics

Mean	Median	Minimum	Maximum
3744.8	4166.0	0.00000	28115.
Std. Dev.	C.V.	Skewness	Ex. kurtosis
2873.4	0.76732	2.3065	19.062
5% Perc.	95% Perc.	IQ range	Missing obs.
1.8000	7028.6	4372.0	0

**ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN MEXICO**

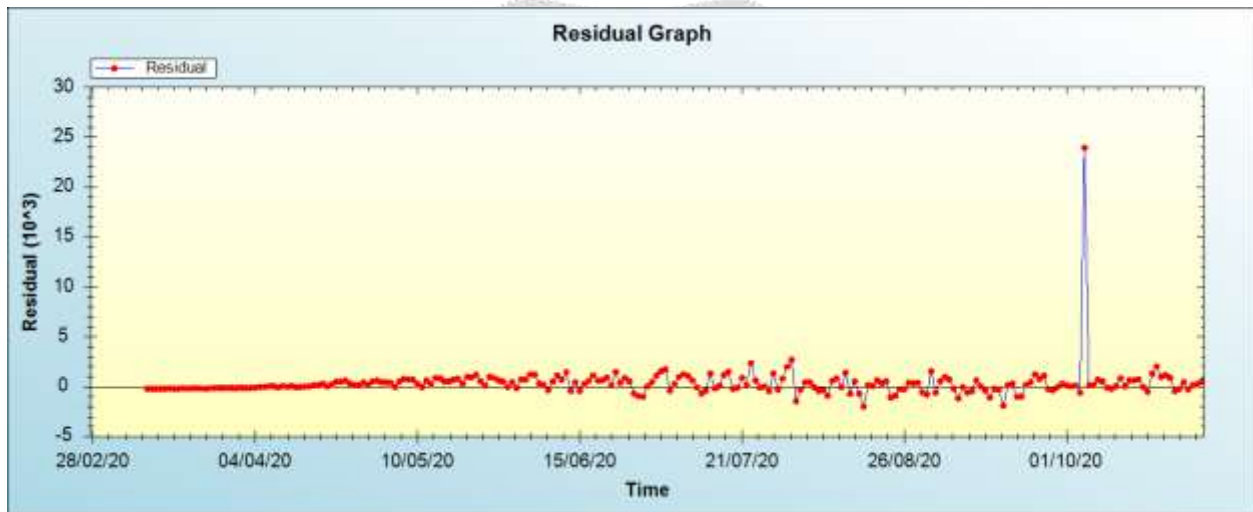
Table 3: ANN model summary

Variable	MC
Observations	235 (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	0.109907
MSE	2947016.663626
MAE	632.062334

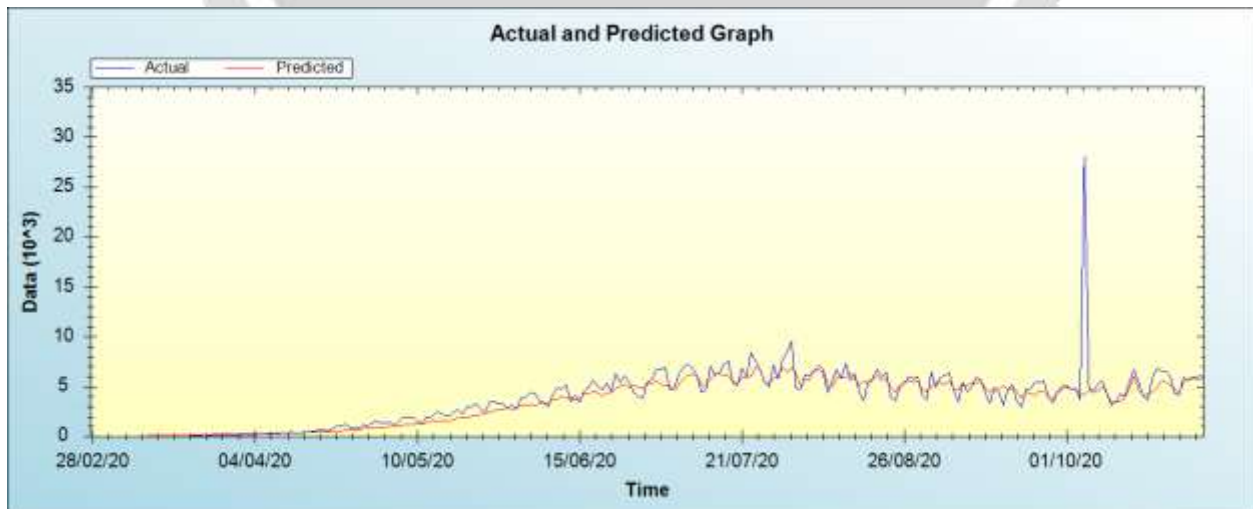
*Residual Analysis for the ANN model*

Figure 1: Residual analysis



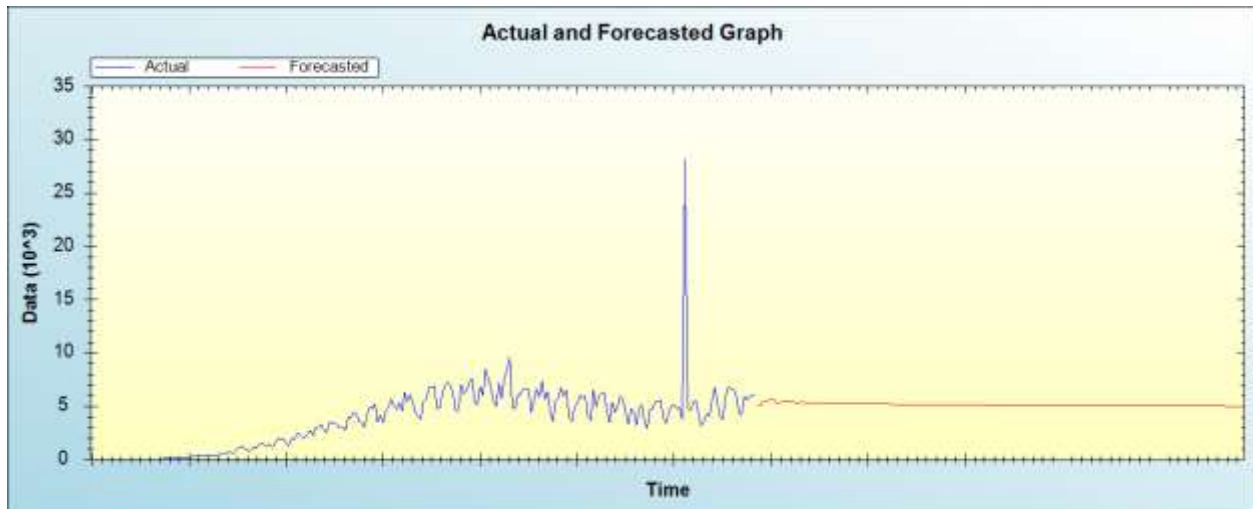
*In-sample Forecast for MC*

Figure 2: In-sample forecast for the MC series



*Out-of-Sample Forecast for MC: Actual and Forecasted Graph*

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



*Out-of-Sample Forecast for MC: Forecasts only*

Table 4: Tabulated out-of-sample forecasts

Day/Month/year	Forecasted daily new COVID-19 cases
01/11/20	5087.0224
02/11/20	5033.5774
03/11/20	5576.0774
04/11/20	5433.4253
05/11/20	5588.1928
06/11/20	5583.5153
07/11/20	5644.9953
08/11/20	5256.1775
09/11/20	5316.4096
10/11/20	5460.9929
11/11/20	5410.0837
12/11/20	5441.3519
13/11/20	5425.5664
14/11/20	5437.9457
15/11/20	5301.4499

16/11/20	5354.3566
17/11/20	5379.9961
18/11/20	5364.9667
19/11/20	5358.9497
20/11/20	5350.2987
21/11/20	5346.5466
22/11/20	5300.7876
23/11/20	5325.3391
24/11/20	5322.4513
25/11/20	5316.6100
26/11/20	5305.3349
27/11/20	5301.3191
28/11/20	5294.5152
29/11/20	5278.9772
30/11/20	5285.7934
01/12/20	5279.0978
02/12/20	5274.7930
03/12/20	5265.9908
04/12/20	5263.1414
05/12/20	5256.9734
06/12/20	5250.5069
07/12/20	5249.8150
08/12/20	5244.2215
09/12/20	5240.1709
10/12/20	5234.1206
11/12/20	5231.2212

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 capital letters below it.

12/12/20	5226.2595
13/12/20	5222.2703
14/12/20	5219.2790
15/12/20	5214.9793
16/12/20	5211.2358
17/12/20	5206.9061
18/12/20	5203.9002
19/12/20	5199.9301
20/12/20	5196.6639
21/12/20	5193.3701
22/12/20	5189.9124
23/12/20	5186.5825
24/12/20	5183.1993
25/12/20	5180.2840
26/12/20	5177.0165
27/12/20	5174.1052
28/12/20	5171.0895
29/12/20	5168.1624
30/12/20	5165.2494
31/12/20	5162.4152
01/01/21	5159.7279
02/01/21	5156.9563
03/01/21	5154.3444
04/01/21	5151.6968
05/01/21	5149.1455
06/01/21	5146.6007

07/01/21	5144.1375
08/01/21	5141.7249
09/01/21	5139.3218
10/01/21	5136.9931
11/01/21	5134.6753
12/01/21	5132.4235
13/01/21	5130.1897
14/01/21	5128.0160
15/01/21	5125.8712
16/01/21	5123.7595
17/01/21	5121.6902
18/01/21	5119.6487
19/01/21	5117.6510
20/01/21	5115.6785
21/01/21	5113.7485
22/01/21	5111.8445
23/01/21	5109.9743
24/01/21	5108.1350
25/01/21	5106.3255
26/01/21	5104.5482
27/01/21	5102.7974
28/01/21	5101.0786
29/01/21	5099.3848
30/01/21	5097.7204
31/01/21	5096.0820
01/02/21	5094.4707



02/02/21	5092.8854
03/02/21	5091.3250
04/02/21	5089.7905
05/02/21	5088.2794
06/02/21	5086.7930
07/02/21	5085.3296
08/02/21	5083.8898
09/02/21	5082.4724
10/02/21	5081.0772
11/02/21	5079.7039
12/02/21	5078.3517
13/02/21	5077.0208
14/02/21	5075.7103
15/02/21	5074.4202
16/02/21	5073.1497
17/02/21	5071.8989
18/02/21	5070.6671
19/02/21	5069.4540
20/02/21	5068.2595
21/02/21	5067.0830
22/02/21	5065.9243
23/02/21	5064.7831
24/02/21	5063.6590
25/02/21	5062.5518
26/02/21	5061.4611
27/02/21	5060.3867

28/02/21	5059.3282
01/03/21	5058.2855
02/03/21	5057.2582
03/03/21	5056.2460
04/03/21	5055.2488
05/03/21	5054.2662
06/03/21	5053.2980
07/03/21	5052.3439
08/03/21	5051.4038
09/03/21	5050.4773
10/03/21	5049.5643
11/03/21	5048.6645
12/03/21	5047.7778
13/03/21	5046.9038
14/03/21	5046.0424
15/03/21	5045.1933
16/03/21	5044.3564
17/03/21	5043.5315
18/03/21	5042.7184
19/03/21	5041.9168
20/03/21	5041.1267
21/03/21	5040.3477
22/03/21	5039.5798
23/03/21	5038.8227
24/03/21	5038.0763
25/03/21	5037.3404



26/03/21	5036.6149
27/03/21	5035.8995
28/03/21	5035.1942
29/03/21	5034.4987
30/03/21	5033.8129
31/03/21	5033.1366
01/04/21	5032.4698
02/04/21	5031.8122
03/04/21	5031.1637
04/04/21	5030.5242
05/04/21	5029.8936
06/04/21	5029.2716
07/04/21	5028.6582
08/04/21	5028.0532
09/04/21	5027.4566
10/04/21	5026.8681
11/04/21	5026.2876
12/04/21	5025.7151
13/04/21	5025.1504
14/04/21	5024.5934
15/04/21	5024.0440
16/04/21	5023.5020
17/04/21	5022.9674
18/04/21	5022.4401
19/04/21	5021.9198
20/04/21	5021.4066

21/04/21	5020.9003
22/04/21	5020.4009
23/04/21	5019.9082
24/04/21	5019.4220
25/04/21	5018.9425
26/04/21	5018.4693
27/04/21	5018.0025
28/04/21	5017.5419
29/04/21	5017.0875
30/04/21	5016.6391

Figure 1 shows that over the study period, the minimum and maximum daily new COVID-19 cases are 0 and 28 115 respectively. The data is positively skewed and kurtosis is greater than 3.0 which means that the data is not normally distributed. The model simulates the observed data well as shown in Figure3. The residual graph shows that the applied ANN (12,12,1) model is adequate, stable and suitable for forecasting daily new COVID-19 cases. The out-of sample forecasts indicate that the new daily coronavirus cases will be constant at around 5000 cases until 30 April 2021.

## CONCLUSION & RECOMMENDATIONS

COVID-19 is still a health problem in Mexico as the projections indicate daily new infections of around 5000 cases until 30 April 2021. Therefore the Mexican government must continue enforcing WHO guidelines on COVID-19 prevention and control to avoid another wave of new infections. If an effective COVID-19 vaccine is found, daily new cases are expected to decline sharply.

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