FORECASTING COVID-19 CASES IN FRANCE: AN APPLICATION OF ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

There is no doubt; the global pandemic of COVID-19 has resulted in a surge in COVID-19 forecasting and control models. In this research article, the ANN methodology was applied to investigate the trends of confirmed daily COVID-19 cases in France. The employed data covers the period January 24, 2020 to October 31, 2020 and the out-of-sample period ranges over the period November 2020 to April 2020. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the employed model reveal that the model is stable in forecasting COVID-19 cases in France. The results of the study basically indicate that daily COVID-19 cases in France will reach an equilibrium level of approximately 131824 cases per day around November 26, 2020 and this shall persist throughout the rest of the out-of-sample period. Nonetheless, the government of France ought to ensure the continued compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so on.

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

INTRODUCTION

Coronavirus Disease 2019 (COVID-19), technically known as SARS-CoV-2, is an infectious disease that was first identified on 31 December 2019 in Wuhan, the capital city of China's Hubei province. The World Health Organization (WHO) declared the coronavirus outbreak a Public Health Emergency of International Concern on 30 January 2020 and a pandemic on 11 March 2020 (Alamo *et al*., 2020). Europe is now considered as the epicenter of COVID-19 and France is amongst the most affected countries (Massonnaud *et al*., 2020). In fact, the first cases of COVID-19 in the European continent were confirmed in France on 24 January 2020. The clinical presentation of COVID-19 ranges between asymptomatic infection, mild symptoms and critical disease, defined by respiratory and or multi-organ failure and death (Huang *et al*., 2020; Wang *et al*., 2020; Chen *et al*., 2020; Lapostolle *et al*., 2020). Disease severity and mortality are associated with older age and underlying comorbidities such as diabetes, hypertension and cardiovascular disease (Sun *et al*., 2020). The virus is mainly spread during close contact and by small droplets produced when those infected cough, sneeze or talk. These small droplets may also be produced during breathing. The virus is most contagious during the first 4 – 6 days after on-set of symptoms, although spread is possible in asymptomatic conditions and in later stages

of the disease (Ferretti *et al*., 2020; Bai *et al*., 2020). The time from exposure to onset of symptoms (incubation period) is typically around 5 days but may range from 2 to 14 days (Lauer *et al*., 2020). The basic reproduction number of COVID-19 has been estimated to be 2.2 (Li *et al*., 2020) but generally ranges between 1.4 and 7.23 (Li *et al*., 2020; WHO, 2020; Hu *et al*., 2020; Wu *et al*., 2020; Read *et al*., 2020; Backer *et al*., 2020; Zhao *et al*., 2020; Riou *et al*., 2020; Song *et al*., 2020; Guan *et al*., 2020; You *et al*., 2020), and human-to-human transmission has since occurred to other parts of China and beyond (Li *et al*., 2020; Chan *et al*., 2020; Phan *et al*., 2020; Liu *et al*., 2020; WHO, 2020). Recommended measures to control the pandemic include social distancing, mobility constraints, pro-active testing and isolation of detected cases (Hellewell *et al*., 2020). COVID-19 forecasting studies are very scanty in France: however, a related research by Massonnaud *et al*. (2020), which as based on a deterministic age-structured SEIR model; found out that by April 2020, the French healthcare system, could be already overwhelmed by the surge in cases. There is need for a more recent forecasting model that would guide policy makers in France as we head towards 2021. The government of France is in great need of reliable forecasts of confirmed COVID-19 case volumes for purposes of planning ahead and strengthening, especially the Intensive Care Unit (ICU) capacities within the French healthcare system. The main objective of this paper is to model and forecast COVID-19 cases in France using Artificial Neural Networks.

METHODOLOGY

This paper applies the multi-layer perceptron neural network type of the ANN approach in order to predict daily new COVID-19 infections in France. The study applies the ANN (12, 12, 1) model and chooses the more efficient hyperbolic tangent function as the activation function. This study is, in fact, based on daily new Covid-19 (referred to as M series in this study) for all age groups in France. The data covers the period 24 January 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 paper was gathered from the COVID-19 data repository prepared by the CSSE at JH University.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

Table 1: Descriptive statistics

Mean	Median	Minimum	Maximum
5056.2	706.50	0.00000	1.2491e+005
Std. Dev.	C.V.	Skewness	Ex. kurtosis
12167.	2.4063	5.1768	37.909
5% Perc.	95% Perc.	IQ range	Missing obs.
0.00000	27722.	3850.8	0

ANN MODEL SUMMARY FOR COVID-19 DAILY CASES IN FRANCE

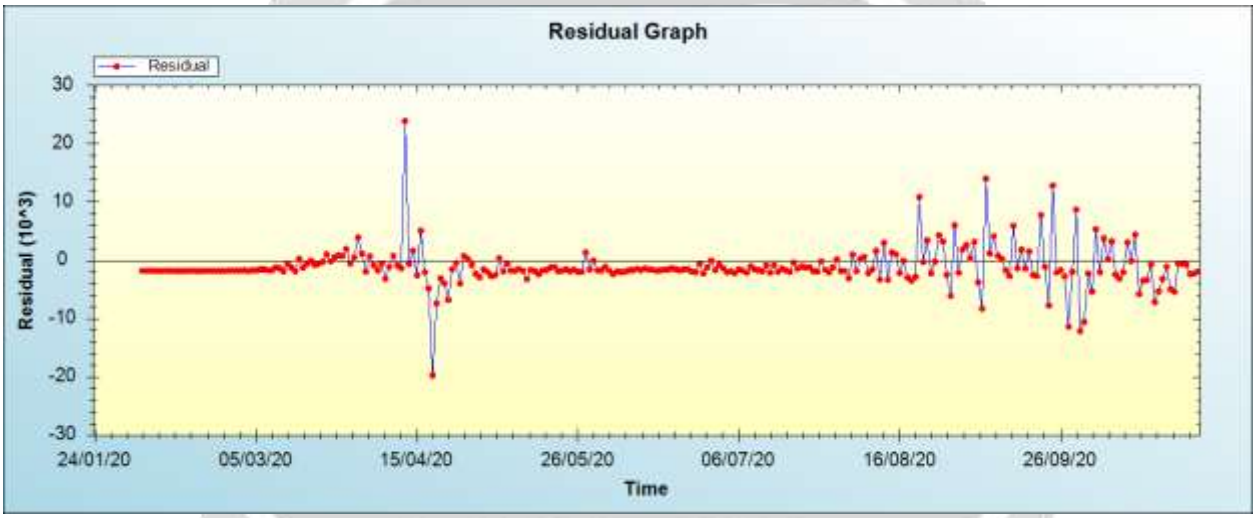
Table 2: ANN model summary

Variable	M
Observations	270 (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	0.051457
MSE	12749732.540766
MAE	2366.845850

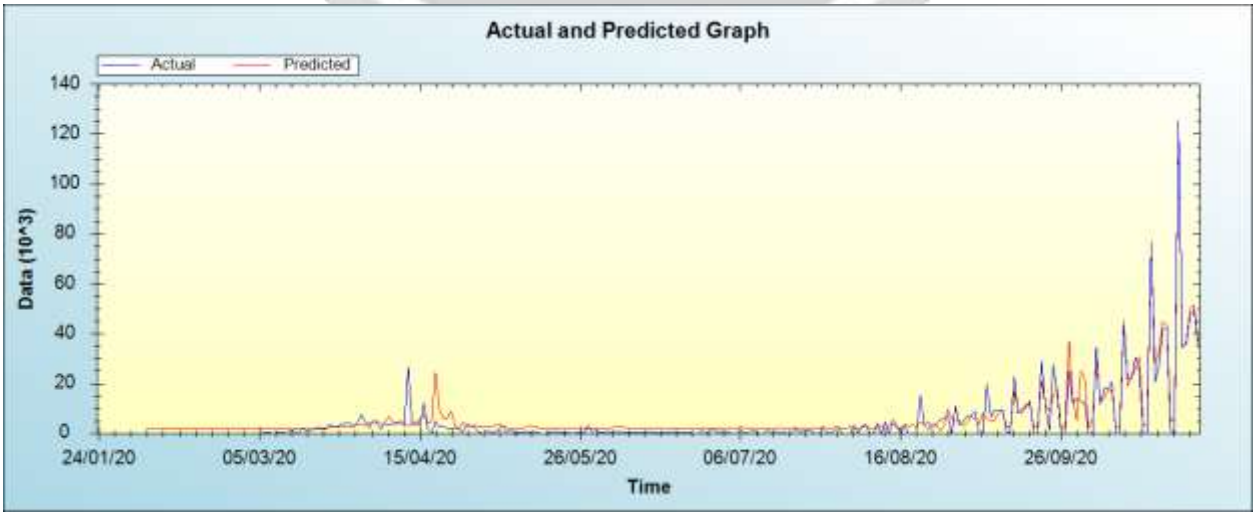
Residual Analysis for the ANN model

Figure 1: Residual analysis



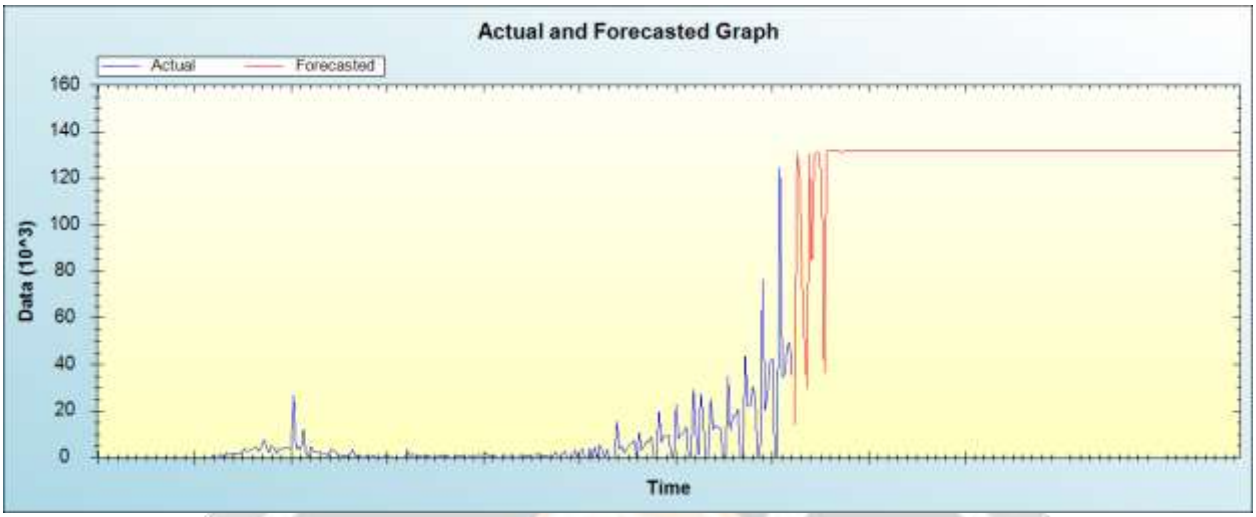
In-sample Forecast for M

Figure 2: In-sample forecast for the M series



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

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



Out-of-Sample Forecast for M: Forecasts only

Table 3: Tabulated out-of-sample forecasts

Day/Month/Year	Forecasts
01/11/20	14216.6421
02/11/20	131238.0449
03/11/20	121487.4867
04/11/20	77786.6424
05/11/20	49638.3745
06/11/20	29672.5208
07/11/20	130567.3035
08/11/20	84914.5056
09/11/20	129696.6456
10/11/20	131402.6377
11/11/20	130294.2316
12/11/20	115859.8744
13/11/20	36215.0875

14/11/20	131786.2045
15/11/20	131734.6650
16/11/20	131785.3191
17/11/20	131746.6590
18/11/20	131786.8981
19/11/20	131813.0860
20/11/20	131001.0957
21/11/20	131814.5986
22/11/20	131823.2048
23/11/20	131801.7165
24/11/20	131820.2186
25/11/20	131817.7040
26/11/20	131824.1015
27/11/20	131823.9642
28/11/20	131824.1008
29/11/20	131824.1382
30/11/20	131824.0448
01/12/20	131824.1581
02/12/20	131824.1091
03/12/20	131824.1106
04/12/20	131824.1135
05/12/20	131824.1120
06/12/20	131824.1127
07/12/20	131824.1123
08/12/20	131824.1123
09/12/20	131824.1123

10/12/20	131824.1123
11/12/20	131824.1123
12/12/20	131824.1123
13/12/20	131824.1123
14/12/20	131824.1123
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01/01/21	131824.1123
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29/04/21	131824.1123
30/04/21	131824.1123

The descriptive statistics, summary of the applied model, residual analysis, in-sample forecasts as well as out-of-sample forecasts are shown in table 1, table 2, figure 1, figure 2 and well as figure 3 and table 3, respectively. The applied predictive model is stable and acceptable as indicated in the residual analysis. The results of the study basically indicate that daily COVID-19 cases in France will reach an equilibrium level of approximately 131824 cases per day around November 26, 2020 and this shall persist throughout the rest of the out-of-sample period. These results are not surprising but rather in line with Massonnaud *et al*. (2020) who noted that by April 2020, the French healthcare system would be overwhelmed already due to the fact that the virus was spreading at a pandemic speed in the country. These results are a warning signal to the government of France, that if they are to lift restrictive measures, something more will happen, that is; a more destructive third wave of infections. It is important to note that the government of France, as of 25 November 2020; has announced its intention to lift the second lockdown imposed in early November. Caution should always be taken in the country as the pandemic is still around and highly prevalent.

CONCLUSION & RECOMMENDATIONS

COVID-19 has led to unprecedented healthcare crisis with millions of infected people across the globe often pushing infrastructures, healthcare workers and entire economies beyond their limits (Tsiknakis *et al*., 2020). France has not been spared by this pandemic and hence the need for forecasting. Based on 282 daily observations of COVID-19 cases in France, this study used the ANN (12, 12, 1) model to come up with forecasts ranging over the period November 2020 to April 2021. Given that Europe is now the epicenter of the virus, we are not surprised to see that, indeed; France will be in real trouble throughout the out-of-sample period. Nevertheless, the government of France should ensure the continued compliance to control and preventive COVID-19 measures such as social distancing, quarantine, isolation, face-mask wearing and so

on. This will help a lot, especially in avoiding extremely catastrophic daily COVID-19 case volumes in the country.

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