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Forecasting Covid-19 Mortality in Japan

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***Abstract* – In this study, the ANN approach was applied to analyze COVID-19 daily deaths in Japan. The employed data covers the period1January 2020 to 20 April 2021 and the out-of-sample period ranges over the period 21 April to 31 August 2021. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is quite stable. The results of the study indicate that daily COVID-19 deaths in Japan are likely to increase from the start of the forecast period to reach an equilibrium point of approximately 260 deaths per day which will stretch from 20/06/21 to 31/08/21. Therefore there is need for the government of Japan to ensure adherence to safety guidelines while continuing to create awareness about the COVID-19 pandemic and accelerate COVID-19 vaccination.**

Keywords: ANN, COVID-19, Forecasting.

I. INTRODUCTION

December 2019 marked the beginning of the COVID-19 global health crisis with its origin being the Chinese city, Wuhan in the Hubei Province (Chen et al, 2020; Huang et al, 2020). The outbreak started as a cluster of pneumonia cases which was associated with mysterious deaths. The causative agent was then discovered to be the novel coronavirus, SARS-COV2 after genetic sequencing (Huang et al, 2020). The virus was seen to be having a transmission rate and high mortality as it spread to many parts of the world. According to previous studies around 80% of cases have mild symptoms and 5% develop severe disease (Yang et al, 2020; Wu &McGoogan, 2020). In Japan the first case of COVID-19 was reported on the 16th of January 2020 (Japan MOH, 2020). By the 7th of July 2020, the country had reported 19 816 confirmed cases and 979 deaths (Japan, 2020; MOH, 2020). It is important to highlight that the predictors of COVID-19 poor prognosis in hospitalized patients are the number of patients, resources of medical personnel, quality of infrastructure and patient background (Matsunaga et al, 2020). In this study we aim to predict daily COVID-19 mortality in Japan using an artificial intelligence technique. The results of the study are expected to reveal the likely future trends of COVID-19 mortality in Japan and assist in the allocation of resources for the COVID-19 response.

II. LITERATURE REVIEW

There are many studies in Japan that were done in order to understand the evolution of the COVID-19.The sero prevalence of anti-SARS-CoV-2 IgG and IgM antibodies in symptomatic Japanese COVID-19 patients was determined by Hiki et al (2021).The presence and titers of IgG antibody for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) were determined by a chemiluminescent micro particle immunoassay (CMIA) using Alinity SARS-CoV-2 IgG and by an immune chromatographic (IC) IgM/IgG antibody assay using the Anti-SARS-CoV-2 Rapid Test. The study concluded that a serologic anti-SARS-CoV-2 antibody analysis can complement PCR for diagnosing COVID-19 14 days after symptom onset. Matsunaga et al (2020)investigated the characteristics of patients with coronavirus disease 2019 (COVID-19) requiring hospitalization in Japan. The study included 2638 cases enrolled from 227 healthcare facilities that participated in the COVID-19 Registry Japan (COVIREGI-JP). The inclusion criteria for enrollment of a case in COVIREGI-JP were both (1) a positive severe acute respiratory syndrome coronavirus and (2) inpatient treatment at a healthcare facility. The results demonstrated fewer comorbidities and a trend towards lower mortality. The relationship between the patient's serum zinc level and severe cases of COVID-19 was examined by Yasui et al (2020). A multivariate logistics regression was used to determine whether serum zinc is a predictive factor for severe COVID-19 disease. The study revealed that prolonged hypozincaemia was a significant predictor for severe COVID-19 disease. Kodera et al (2020) analyzed the morbidity and mortality rates of the coronavirus disease (COVID-19) pandemic in different prefectures of Japan. Under the constraint that daily maximum confirmed deaths and daily maximum cases should exceed 4 and 10, respectively, 14 prefectures were included, and cofactors affecting the morbidity and mortality rates were evaluated. Lower morbidity and mortality rates were observed for higher temperature and absolute humidity.

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III. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting COVID-19 deaths in Japan.

Data Issues

This study is based on daily COVID-19 deaths in Japan for the period 1 January 2020 – 20 April 2021. The out-of-sample forecast covers the period 21 April – 31 August 2021. All the data employed in this research paper was gathered from the Johns Hopkins University (USA).

IV. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	J
Observations	464(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	0.629117
MSE	89.077623
MAE	7.187239

Residual Analysis for the Applied Model

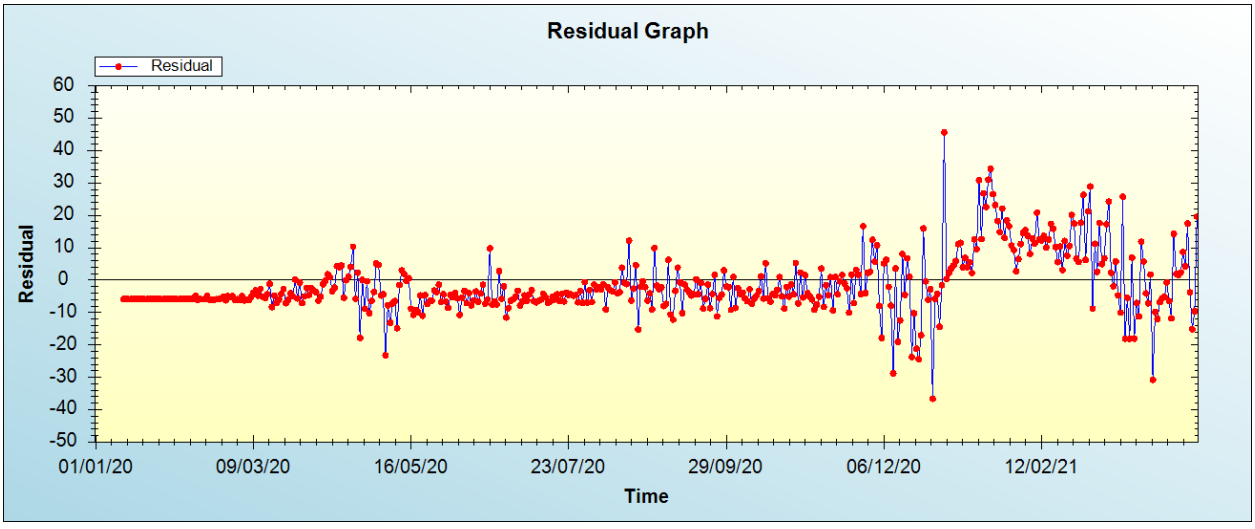

Figure 1: Residual analysis

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In-sample Forecast for J

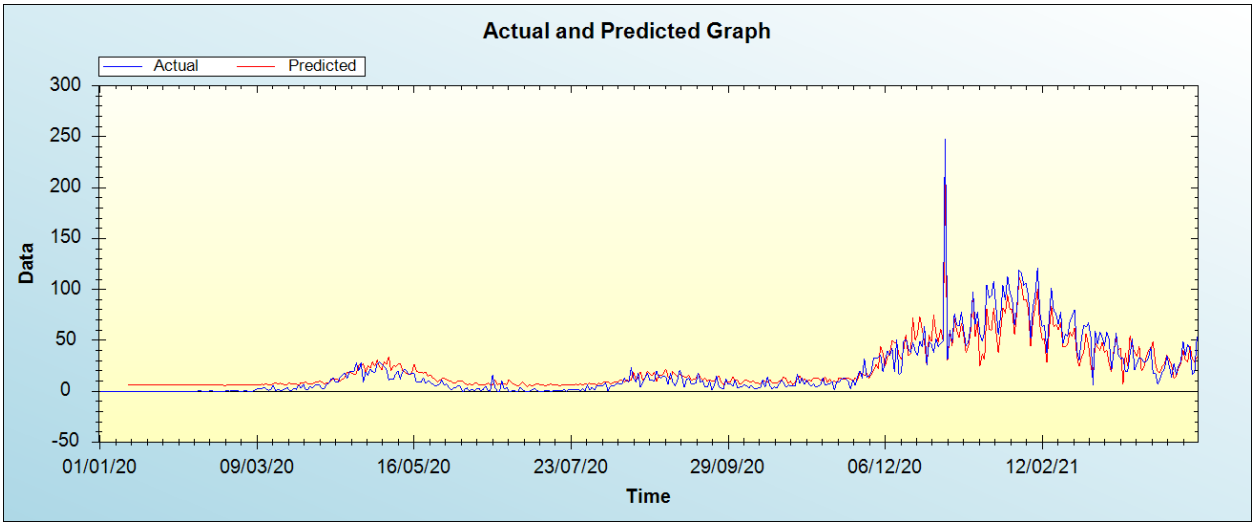

Figure 2: In-sample forecast for the J series

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

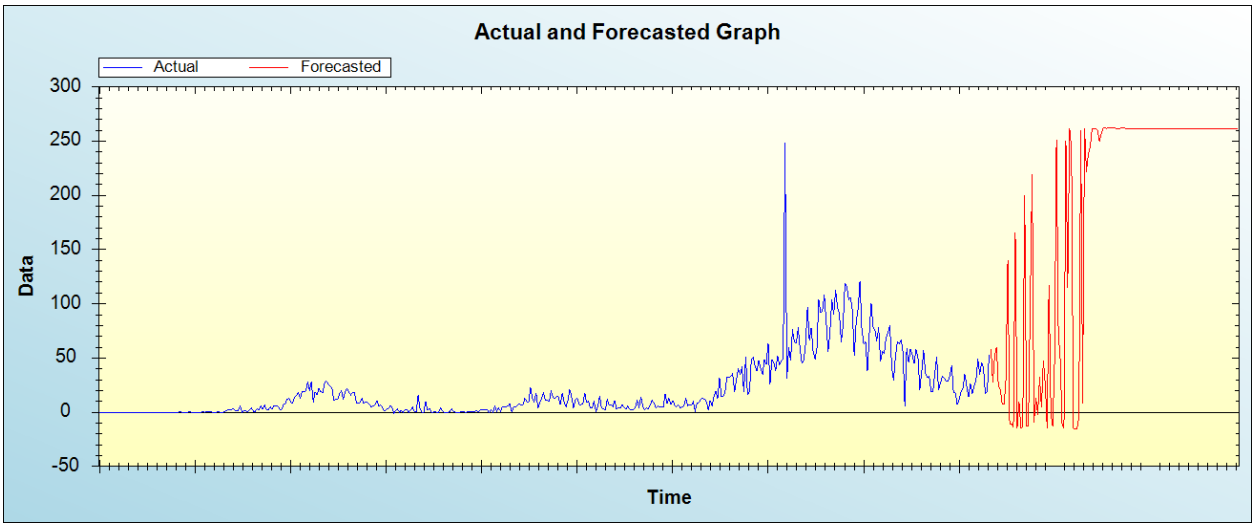

Figure 3: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for J: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Day/Month/Year	Projected COVID-19 deaths
21/04/21	58.1102
22/04/21	27.6510
23/04/21	52.3750
24/04/21	60.2403
25/04/21	23.4952
26/04/21	21.2817
27/04/21	7.5121
28/04/21	7.6974
29/04/21	30.6190
30/04/21	140.5310
01/05/21	-11.5264
02/05/21	-10.0906
03/05/21	-14.0247
04/05/21	165.9256

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05/05/21	-14.3201
06/05/21	9.5800
07/05/21	-14.5609
08/05/21	-13.6184
09/05/21	200.3530
10/05/21	-12.5135
11/05/21	-12.5818
12/05/21	103.8326
13/05/21	219.4793
14/05/21	-8.8880
15/05/21	13.4369
16/05/21	-1.9737
17/05/21	32.2295
18/05/21	4.5892
19/05/21	47.8020
20/05/21	25.8759
21/05/21	-14.7442
22/05/21	117.5759
23/05/21	-1.2189
24/05/21	-13.2659
25/05/21	48.7805
26/05/21	251.2647
27/05/21	74.1633
28/05/21	49.5294
29/05/21	-10.3004
30/05/21	-14.6709
31/05/21	250.6015
01/06/21	115.0412
02/06/21	261.8245
03/06/21	242.5114
04/06/21	-14.8272
05/06/21	-14.8044
06/06/21	-14.8307
07/06/21	-3.8402
08/06/21	259.8459
09/06/21	8.1030
10/06/21	261.4498
11/06/21	221.6353
12/06/21	238.7506
13/06/21	244.4659
14/06/21	261.7369
15/06/21	261.8212
16/06/21	261.3341
17/06/21	259.8669
18/06/21	249.5312
19/06/21	257.5180
20/06/21	261.8153
21/06/21	261.8291
22/06/21	261.8176
23/06/21	261.8296
24/06/21	261.8309
25/06/21	261.8316
26/06/21	261.8288
27/06/21	261.8256
28/06/21	261.8216
29/06/21	261.8248
30/06/21	261.8293
01/07/21	261.8274
02/07/21	261.8259
03/07/21	261.8258
04/07/21	261.8259
05/07/21	261.8259
06/07/21	261.8259
07/07/21	261.8259

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08/07/21	261.8259
09/07/21	261.8259
10/07/21	261.8259
11/07/21	261.8259
12/07/21	261.8259
13/07/21	261.8259
14/07/21	261.8259
15/07/21	261.8259
16/07/21	261.8259
17/07/21	261.8259
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26/08/21	261.8259
27/08/21	261.8259
28/08/21	261.8259
29/08/21	261.8259
30/08/21	261.8259
31/08/21	261.8259

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that daily COVID-19 deaths in Japan are likely to increase from the start of the forecast period to reach an equilibrium point of approximately 260 deaths per day which will stretch from 20/06/21 to 31/08/21.

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V. CONCLUSION AND POLICY RECOMMENDATIONS

The global COVID-19 outbreak is associated with high morbidity and mortality. Several models have been used by various researchers to forecast COVID-19 mortality and such techniques include statistical and machine learning methods. In this study we propose a machine learning technique to predict daily COVID-19 deaths in Japan. The ANN model projections suggest that that daily COVID-19 deaths in Japan are likely to increase from the start of the forecast period to reach an equilibrium point of approximately 260 deaths per day which will stretch from 20/06/21 to 31/08/21. Hence the Japanese government must scale up COVID-19 vaccination and enforce adherence to recommended WHO guidelines on prevention and control of COVID-19.

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