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Forecasting of Covid-19 cases based on prediction using artificial neural network curve fitting technique

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ABSTRACT

Artificial neural network is considered one of the most efficient methods in processing huge data sets that can be analyzed computationally to reveal patterns, trends, prediction, forecasting etc. It has a great prospective in engineering as well as in medical applications. The present work employs artificial neural network-based curve fitting techniques in prediction and forecasting of the Covid-19 number of rising cases and death cases in India, USA, France, and UK, considering the progressive trends of China and South Korea. In this paper, three cases are considered to analyze the outbreak of Covid-19 pandemic viz., (i) forecasting as per the present trend of rising cases of different countries (ii) forecasting of one week following up with the improvement trends as per China and South Korea, and (iii) forecasting if followed up the progressive trends as per China and South Korea before a week. The results have shown that ANN can efficiently forecast the future cases of COVID 19 outbreak of any country. The study shows that the confirmed cases of India, USA, France and UK could be about 50,000 to 1,60,000, 12,00,000 to 17,00,000, 1,40,000 to 1,50,000 and 2,40,000 to 2,50,000 respectively and may take about 2 to 10 months based on progressive trends of China and South Korea. Similarly, the death toll for these countries just before controlling could be about 1600 to 4000 for India, 1,00,000 to 1,35,000 for USA, 40,000 to 55,000 for France, 35,000 to 47,000 for UK during the same period of study.

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INTRODUCTION

The spread of the 2019 novel coronavirus is being witnessed all over the world. Recently, on 11th February 2020, the International Committee on Taxonomy of Viruses (ICTV) termed this virus as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). On the same day, the World Health Organization (WHO) declared Corona Virus Disease as COVID-19. With a figure of 118, 000 cases of COVID-19 infection from 114 Countries and 4, 291 fatalities as on 11th February 2020, WHO declared COVID-19 as a pandemic. SARS-CoV-2 comes from the family of Coronavirus which belongs to the order of Nidovirales. It possess spikes on outer surfaces that resemble a crown (corona) formed during solar eclipse gives the name coronavirus. In length the size varies from 26 – 32 kilobase with a nucleus of 65 – 125 nm in diameter containing single-stranded Ribonucleic Acid (RNA). Alpha (α), Beta (β), Gamma (γ) and Delta (δ) coronavirus are the presently known subgroups of Coronavirus family. The SARS-CoV, H5N1 influenza A, H1N1 2009, and Middle East respiratory syndrome coronavirus (MERS-CoV) cause acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) which leads to pulmonary failure and result in fatality. These viruses were thought to infect only animals until the world witnessed a severe acute respiratory syndrome (SARS) outbreak caused by SARS-CoV, 2002 in Guangdong, China (Zhao *et al.,* 2003). Again, an endemic was caused in Middle-East, 2013 by another pathogenic coronavirus named MERS-CoV (Yuan *et al.,* 2006). Recently, Wuhan in the Hubei province of China witnessed an outbreak of SARS-CoV-2 caused by the β-coronaviruses subgroup. SARS-CoV of 2003 infected 8098 humans from 26 countries with a mortality rate of 9%, while SARS-CoV-2 of 2019 has infected 4,233,997 humans from 212 countries with fatalities of 285, 889 i.e. mortality rate of 16% as up to the date of this writing. With its alarming high transmission ability and no known treatment of antiviral vaccines, the outbreak possesses a great threat to mankind. India stands with 44029 active cases of COVID-19 as of 12th May 2020 which is about 14 weeks from its first reported case of a migrated infected from Wuhan, China on 30th January 2020. With 20, 916 recoveries, and 2, 206 deaths, India becomes 12th most infected country immediately after China as on 12th May 2020. On 24th March 2020, the Government of India ordered a nationwide lockdown for 21 days, limiting movement of the entire 1.3 billion population of India as a preventive measure against the COVID-19 pandemic. The same has been extended twice and is the latest up to 17th May 2020. Increasing the need for testing and quarantine facilities has emerged as a great challenge for the Country. In this situation, statistical or some other prediction tools for forecasting the upcoming situation can be of great help in proper planning and design of measures for the control COVID-19 (Wang *et al.,* 2020) (Zhu et al., 2019). The effect of weather trends and its correlation to the spread of COVID-19 in the USA through statistical analysis and prediction analysis for India has been studied. (Gupta *et al.*, 2020). The study showed that a significant correlation between weather parameters like absolute humidity and temperature range with a spread of COVID-19 could only be established when daily infection ranges to 10000 or more which is much high as compared to the present scenario of India. With very low cases reported as of 9th April 2020, the study showed no apparent COVID-19 spread based on weather variations as of USA. Another study developed a Patient Information based Algorithm (PIBA) model based on data of Wuhan, China (Wang *et al.*, 2020). With data from the patient's initial admission to death, this model showed its capability of accurately estimating the mortality rate and future deaths. The model has been deployed for estimating the death rates for symptomatic as well as asymptomatic patients of China and South Korea. A case study of South Africa and a few other countries presented Susceptible Exposed Infectious Recovered (SEIR) model (Zhao *et al.*, 2020). This was an improved SEIR model (Peng *et al.*, 2013) (Jing et al., 2020) than that of the traditional SEIR model which had low accuracy due to ignorance of quarantine status and intervention measures. Wavelet decomposition and autoregressive integrated moving average (ARIMA) models were also deployed (Singh *et al.*, 2020) for COVID-19 spread prediction of five countries i.e. France, Italy, Spain, UK, and USA for the period of 12th April 2020 to 11th May 2020. The earlier model showed higher accuracy of prediction than AIMA models for all of the five countries. A data-driven LSTM method and the classical curve fitting method for the prediction of several patients to be accommodated in the subsequent days based on the data available were also done (Tomar *et al.*, 2020).

With prevailing situations and ever-changing patterns, the need for more research in this area is quite eminent. A parsimonious model with consideration of quarantine conditions of both symptomatic individuals and isolation practices for the rest of the population has been explored (Benjamin *et al.*, 2020). Work suggested that with the implementation of effective containment policies, the spread could be minimized from the exponential rate of growth to the sub-exponential level. The temporal dynamics of COVID-19 for China and Italy have also been analyzed (Duccio *et al.*, 2020). The health sector required 2500 ventilation units for health authorities of Italy for significant improvement in recovery rate. Short term forecasts based on real-time data of COVID-19 spread for multiple countries were tried out (Chakraborty *et al.*, 2020). Risk assessment in terms of fatality rate has been presented for some profoundly affected countries by finding various important demographic characteristics of the countries along with some disease characteristics another study highlighted that with the lockdown of Italy, a total decrement of 35 % in several registered cases and an increment of 66 % in several recovered cases could be made possible (Chintalapudi *et al.*, 2020). Another work compared the effectiveness of six machine learning approaches as well as the ARIMA statistical model, were employed in the task of forecasting one, three, and six-days-ahead the COVID-19 cumulative confirmed cases in ten Brazilian states with a high daily incidence (Matheus *et al.*, 2020). Estimation work is also present suggesting that COVID-19 will be over probably in late-April, 2020 in Wuhan and before late-March, 2020 in other areas respectively. (Isaifan, 2020) has studied the impact of air quality and its effect on the outbreak of the Coronavirus. Artificial intelligence (AI) inspired methods for real-time forecasting of COVID-19 to estimate the size, lengths, and ending time of COVID-19 across China has also been deployed (Zixin *et al.,* 2020). Various key parameters were found like the latent time, the quarantine time and the basic reproduction number in a relatively reliable way, and predict the inflection point, possible ending time and final total infected cases for Hubei, Wuhan, Beijing, Shanghai, etc. (Peng *et al.,* 2020). Researchers came up with a numerical model for the spread of the COVID-19 (Ivorraa *et al.,* 2020) (Zu *et al.,* 2020). They utilized a compartmental model (yet not a SIR, SEIR or other broadly useful models) and consider the Liangrong known exceptional qualities of this malady, as the presence of irresistible undetected cases. Studies conducted on daily reports of conclusive COVID-19 patients of Iran were merged with Plague projection models to anticipate the number of cases from April 3, 2020, until May 13, 2020 (Ahmadi *et al.,* 2020). Forecast modelling for early advancement of the COVID-19 pandemic in Brazil utilizing Brazilian late information from February 25, 2020, to March 30, 2020, has been presented in work (Bastos *et al.,* 2020). Previous works from the literature survey gave a target approach with foreseeing the continuation of the COVID-19 by utilizing Hotheyver groundbreaking strategy to do as such (Petropoulosl *et al.,* 2020). Expecting that the information utilized is solid and that the future will keep on following the past example of the ailment, our estimates propose a proceeding with increment in the affirmed COVID-19 cases with sizable related vulnerability. Recently approved phenomenological models to create momentary conjectures of aggregate announced cases in Guangdong and Zhejiang, China were also analyzed (Kimberlyn *et al.,* 2020). Utilizing day by day detailed combined case information up until 13 February 2020 from the National Health Commission of China, they reported 10 days ahead conjectures of combined case reports. Investigations present a correlation of day level estimating models on COVID-19 influenced cases utilizing time arrangement models and scientific detailing (Haytham *et al.,* 2020). The gauging models and information firmly recommend that the quantity of coronavirus cases develops exponentially in nations that don't command isolates, limitations on movement and open social occasions, and shutting of schools and colleges. Observations made on scaling law in affirmed cases are an immediate mark of compelling containment procedures as they'll as methodical conduct changes that influence a significant division of the vulnerable populace (Benjamin *et al.,* 2020). These bits of knowledge may help the usage of control methodologies in potential fare instigated by COVID-19 if such infections flare-ups somewhere else or then again comparative future episodes of other rising irresistible infections. Researchers have explored the spatial epidemic dynamics of COVID-19 in mainland China (Kang *et al.,* 2020). Moran's I spatial statistic with various definitions of neighbors was used to conduct a test to determine whether a spatial

association of the COVID-19 infections existed. Compilation of literature on different public health measures in Vietnam compared to the progression of COVID-19 from January to March 2020 is also available (Ha-Linh Quach *et al.,* 2020). Work has been presented an in-depth investigation of the transmission of the novel coronavirus (COVID-19) from the urban perspective (Liu *et al.,* 2020). Researchers outlined some of how the current pandemic has negatively impacted the welfare of pets (Nicola, 2020). It also highlights the relationships between animal, human, and environmental health, as well as the importance of taking a collaborative transdisciplinary. One Health approach to help prevent future COVID-19 outbreaks. Another work proposed a compartmental mathematical model for the spread of the COVID-19 disease with a special focus on the transmissibility of super-spreaders individuals (Faïçal *et al.,* 2020). They computed the basic reproduction number threshold, we study the local stability of the disease-free equilibrium in terms of the basic reproduction number and investigated the sensitivity of the model for the variation of each one of its parameters. Numerical simulations show the suitability of the proposed COVID-19 model for the outbreak that occurred in Wuhan, China. Previous work has predicted the expected number of daily infections per country and the duration of the epidemic in each country (Barmparis *et al.,* 2020). This quantitative approach was based on a Gaussian spreading hypothesis which showed to arise as a result of imposed measures in a simple dynamical infection model In this study, artificial neural network (ANN) based curve fitting model has been proposed for prediction of COVID-19 spread and deaths cases in India, USA, UK and France based on the data trend up to the first week of May 2020. A detailed study has been carried out where the proposed model has been trained with data trends of China and South Korea during the same period. The rate of spread and future deaths of India for the above period has been compared with that of China and South Korea. Therefore, three cases of COVID-19 confirmed and death cases are analyzed for forecasting current data trends of the first week of May 2020 to the future data trends viz., i) case forecasting as per the trend of rising cases of different countries during and before the first week of May 2020 ii) case forecasting of one week following up with the improvement trends as per China and South Korea in February and March 2020, and iii) case forecasting if had followed up progressive trends as per China and South Korea a week before in February and March 2020

MATERIALS AND METHODS

Artificial neural network curve fitting model

The artificial neural network (ANN) is a data processing system consisting of a large number of simple and highly interconnected processing elements resembling a biological neural system. It has the capability of learning from an experimental or real data set to describe the nonlinear and interaction effects with great success. ANN-based curve fitting technique is one of the extensively used artificial intelligence methods that are engaged for forecasting and prediction purpose. .It consists of mainly three layers i.e., input layer, hidden layers, and output layer, the present work includes the number of days as input layer and the daily number of Covid19 cases as output data for the network. In ANN curve fitting the training data followed the trend of the given forecasted data and allows to make predictions of how the data series will act in the future. In the present study least square error method is employed to develop the polynomial curve. During the training process, the network adjusts its weights to minimize the errors between the predicted and desired outputs. The optimum network is arrived upon a minimum error by randomly varying weights. ANN with backpropagation algorithm is used to train the network, and the network is used for forecasting exptrapolated data sets and the prediction is compared with real data available at WHO official site (WHO, 2020). The network with neurons (nodes) in each layer is interconnected with nodes of the subsequent and preceding layer with synaptic weights. Additionally, a bias is added to each neuron of the hidden and output layer. The output of each neuron is obtained by summing up weighted inputs of neurons in the preceding layer and its own bias. The output of each neuron in the hidden or output layer is computed by Eq. 1.

$$O_j = f(I) = f\left(\sum_{i=1}^{n} w_{ij} x_i + b_j\right) \quad (1)$$

where w_{ij} is the associated weights with j^{th} neurons of the layer and i^{th} neurons of the preceding

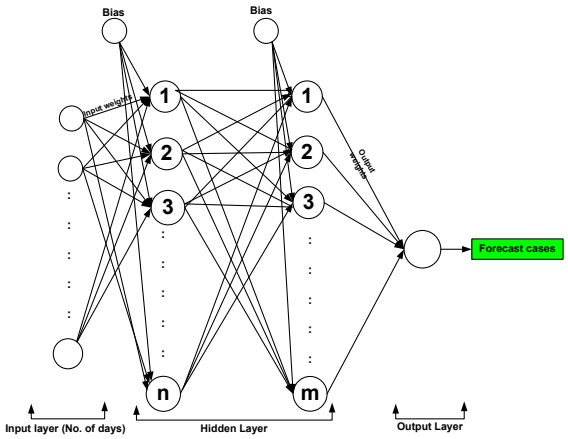


Fig. 1: ANN architecture.

layer, b_j is the bias of jth neurons, n is the total number of neurons of the preceding layer, and f is the appropriate transfer function used. Fig. 1 shows the architecture of the two-layered feed-forward neural network system used in this work. The network is developed with a neural network curve fitting tool available in MATLAB.14 that works on the backpropagation learning algorithm.

The algorithm uses gradient descent technique and minimizes mean square error (MSE) between actual network outputs with the desired output pattern using Eq. 2.

$$E_p = \frac{1}{2}\sum (t_{pj} - O_{pj})^2 \quad (2)$$

Where, E_p is the error for the pth presentation vector, t_{pj} is the desired value for the jth output neuron, and o_{pj} is the desired output of the jth output neuron.

The next step is to determine the error available at the neurons of the hidden layer and back-propagate those errors to the weight values connected in between the neurons of the hidden layer and the input layer. Similarly, backpropagate the errors available at the output neurons to the weight values connected in between the neurons of the hidden layer and output layer using Eqs. 3 and 4.

$$Error\delta_{pi} = (t_{pj} - O_{pj})O_{pj}(1 - O_{pj}) \text{ ; for output neurons} \quad (3)$$

$$Error\delta_{pi} = (t_{pj} - O_{pj})O_{pj}\sum \delta_{pi}W_{ki} \text{ ; for hidden neurons} \quad (4)$$

Weight adjustment is made using Eq. 5.

$$\Delta W_{ji}(n=1) = \eta(\delta_{pi}O_{pi}) = \alpha\Delta W_{ji}(n) \quad (5)$$

Where, η is the learning rate parameter and α is momentum factor.

RESULTS AND DISCUSSION

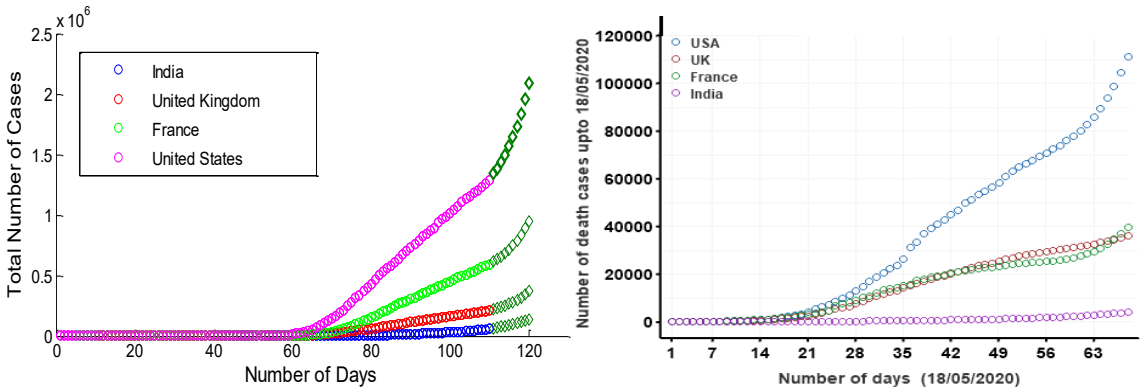
In the present study, the forecast model is developed and analyzed using the COVID 19 dataset which is collected from the website of WHO. The result has been comprehensively analyzed using artificial intelligence techniques to develop forecasting models of the next 10 days i.e. up to 18th May 2020, for largely infected populous countries such as USA, UK, France, and India. From the report available from a daily press release of WHO, China and South Korea have shown a progressive improvement in controlling the pandemic and flattening their curves. Based on the analytic study of the growth trends of these two countries, the various forecasts on the growth trend of COVID 19 cases in the selected populous countries are presented. The findings are discussed as below.

Finding 1: The proposed model has been used for forecasting the number of confirmed cases and death cases for the next 10 days i.e., up to 18th May 2020. The forecasted results obtained for USA, UK, France, and China are depicted in Fig. 2 (i-ii). Table 1 presented 10 days prediction of COVID-19 cases from 10/05/2020 to 18/05/2020 using neural networks in the selected countries.

Finding 2: Growth pattern of COVID 19 cases forecasted for USA, UK, France, and India as per the curve pattern of China and Korea using neural network curve fitting technique.

Case: I Growing the rate of confirmed cases in USA, UK and France as per China and Korea pattern.

The COVID 19 outbreak *was* first identified in Wuhan, *China*, in December 2019. Since then, many researchers and scientist have started their research in different ways. In the present work, an attempt has been made to fit the curve as per the pattern of progressively improved countries like China and South Korea with largely infected countries such as USA, UK, France, and India to forecast their trends. Subsequently, the approximate number of days required to flatten the curve can be found out.



(i) Confirm cases up to 18/05/2020 (ii) Death Cases up to 18/05/2020

Fig 2: Forecasting results of the (i) confirmed and (ii) death cases of USA, UK, France, and India

Table 1: Forecasting data for the coming days of the confirmed cases in the studied countries: 10 / 5 / 2020 – 18 / 5 / 2020.

	Number of confirm cases				Number of death cases			
Date	USA	UK	France	India	USA	UK	France	India
10/05/2020	1340381	614320	221245	65024	77871	31183	26725.4	2203.87
11/05/2020	1386721	635366	230068	70216	80171	31641	27424.8	2364.97
12/05/2020	1439255	658990	240160	76008	82806	32118	28308.2	2540.11
13/05/2020	1499100	685710	251753	82480	85859	32622	29411.7	2730.56
14/05/2020	1567494	716105	265107	89719	89424	33166	30774.9	2937.65
15/05/2020	1645799	750818	280505	97824	93602	33759	31441.0	3162.80
16/05/2020	1735512	790561	298262	106901	98508	34415	31957.3	3407.53
17/05/2020	1838271	836118	318725	117067	104268	35147	32474.7	3673.41
18/05/2020	1955865	888353	342272	128450	111021	35969	33101	3962.14

Fig. 3 (i-iii) shows the present data of USA, UK, and France respectively and also forecast the trends of the countries presuming to follow China's and South Korea's strategies to fight against the pandemic. As evidence from the forecasted plots, it is obvious that if the country couldn't implement strict actions like lockdown, social distancing, and other necessary regulations issued by WHO, then the epidemic growth could be worse as the cases are rising exponentially in these countries. But on the other hand, if the countries are presumed to take controlling steps at least at par with China and S. Korea, the cases could be kept under control. From the result, it is found that if the countries follow China's and S. Korea's trends then USA will take around 30 days and 86 days respectively, 108 days and 115 days for UK and 53 days and 65 days respectively for France to slow down the epidemic.

Case: II Forecast of trends of confirmed cases in India as per China's and S.Korea's trends

In this case, three types of forecasts are presented and analyzed each as per China's and South Korea's trends respectively. The three forecasts viz. Forecast-1, Forecast-2, and Forecast-3 are determined by applying ANN curve fitting techniques considering three performances. Forecast-1 presumes India's trend follows closely similar to China's or South Korea's trend. Forecast-2 considers as if India is performing better by one week ahead of China or South Korea. Forecast-3 considers a case in which India's curve gets worsen by one week than that of China's or South Korea's trend. In Fig. 4(i), Forecast-1 is predicted as per the present trend of India and when China happened to just cross 40,000 confirmed cases on 10th February 2020. In other words, it is presumed that India follows China's trend. If India happens to follow this trend, the

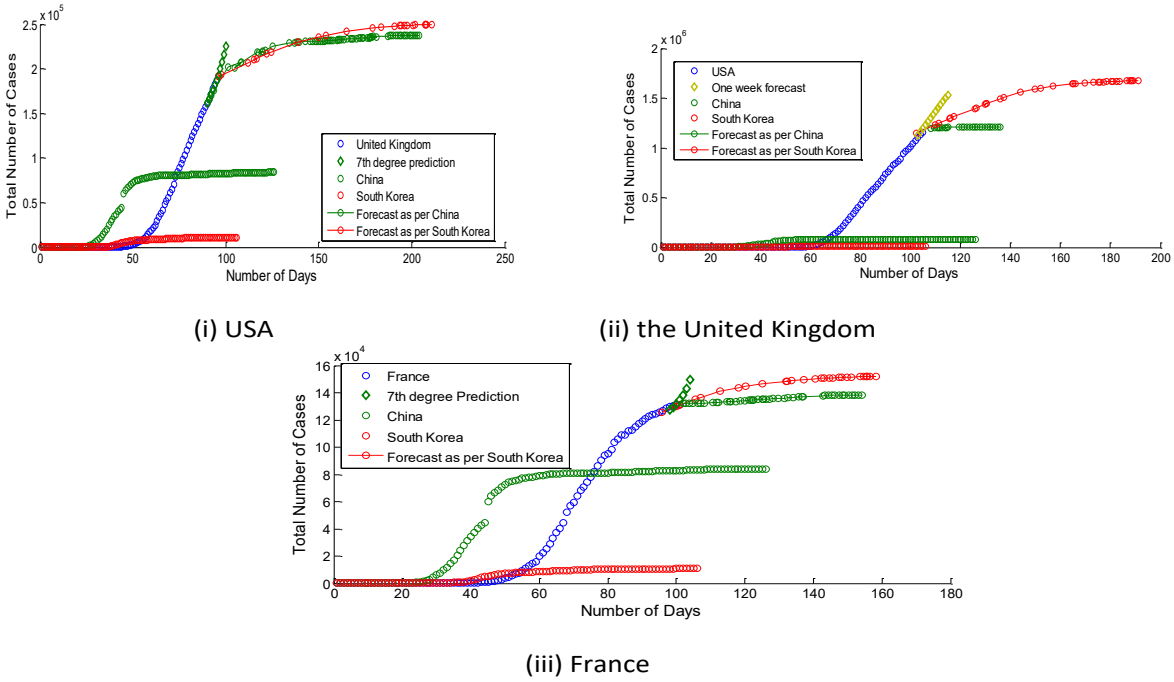


Fig. 3: (i) USA, (ii) UK and (iii) France outline as per China and Korea

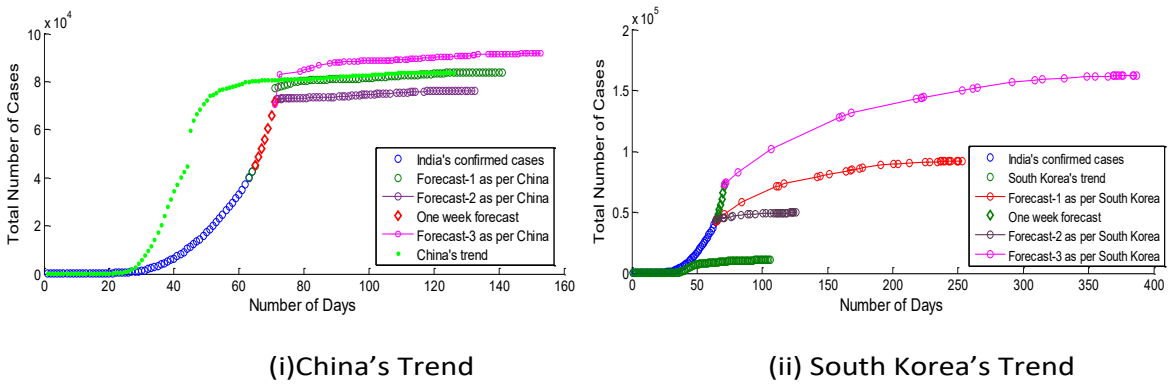


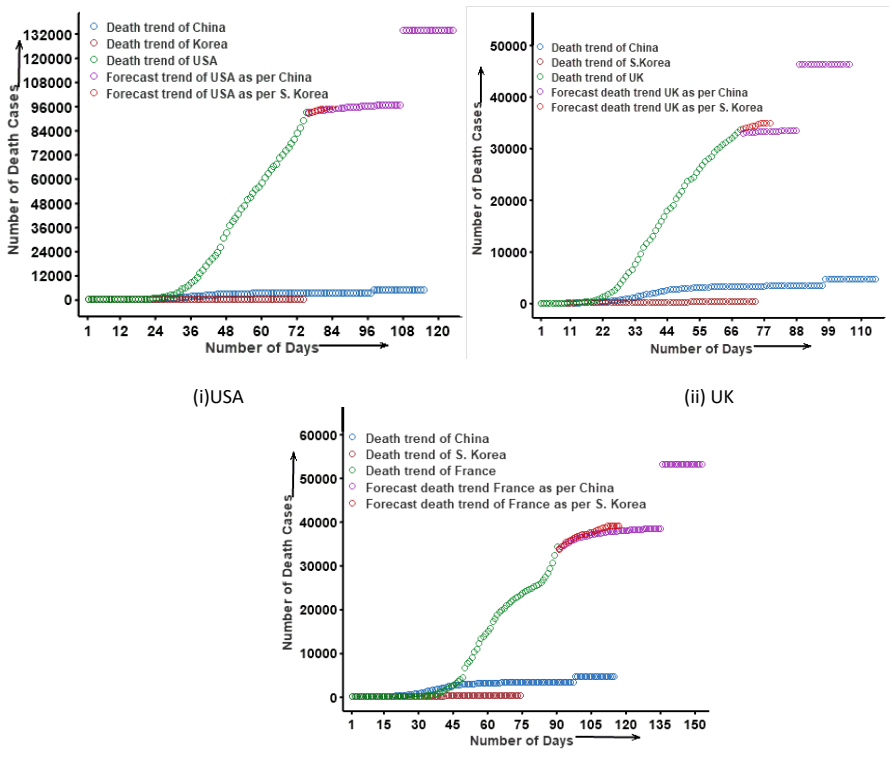
Fig. 4: Forecasts for India's trend of confirmed cases (i) as per China's trend (ii) South Korea's trend

condition of China in the first week of May 2020 will be expected to observe in the third week of July 2020 in India which is about 72 days later as depicted from Fig.4 (i) represented by the curve of Forecast-1. In the case of Forecast-2, as shown in Fig 4(i), when China happened to report total cases of about 70,000 in the around third week of February 2020, India remains near about 50,000 in the around the second week of May 2020. As per this forecast, India will observe China's situation between the 1st and 2nd weeks of July 2020 with total expected cases of 76289, which China had experienced in the first week of May 2020 with total cases more than 80,000. Hence, as per Forecast-2, India would be performing better if even it follows China's trend one week ahead. Whereas, Forecast-3 considers a case in which India's trend gets worsen by one week back when China had to face more rising cases. As depicted from the plot of Forecast-3 in Fig

4(i), India would have crossed total cases of 90,000 in between the last week of July and August 2020 when China had just crossed 80,000 in the first week of May 2020. Thus, India will be observing a worse situation compared to China as per Forecast-3. A similar analysis is carried out as per South Korea's trend as shown in Fig. 4(ii). Since the total cases of South Korea are comparatively less compared to India, a threshold point is considered as per the rising trend of both the countries. For the analysis, India's trend in the first week of May 2020 is compared with that of South Korea's trend in the second week of March 2020 as per the rising cases. Accordingly, as per Forecast-1 as shown in Fig. 4(ii), India would be reporting total cases of 91,912 after 182 days which will be in between the second and third weeks of November 2020. In the case of Forecast-2, India's total cases are predicted as 49726 in the first week of July 2020, which is however not an easy step as South Korea has almost achieved a flat trend with a few numbers of new cases in the first week of May 2020. On the other hand, Forecast-3 could result in a total case of 1,62,222 in the next 316 days i.e., till March 2021. As evidence from the above cases for both China and South Korea, the measures taken up by China is more stringent and effective for a large number of cases whereas that of South Korea is more or less of a slow and gradual process and more effective to control the situation at an early stage. Hence, as per the forecasts of India's trend, the situation can be controlled with less time with China's trend as compared to South Korea's trend.

Case: III Death cases in USA, UK, and France as per China and S. Korea pattern

As in case I, a similar curve fitting technique is employed to predict the number of death cases for USA, UK, and France. The forecasts for these countries are determined by training the trends of two progressively improved countries viz. China and S. Korea in the neural network curve fitting technique. Fig.5 (i-iii) shows the number of death cases at present (i.e. first week of May 2020) and

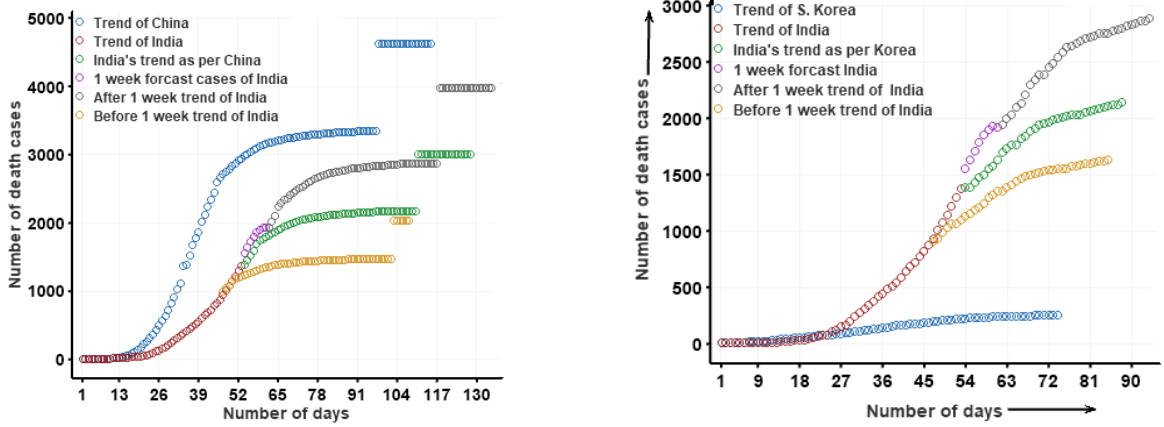


(i)USA

(ii) UK

(iii) France

Fig. 5: (i) USA, (ii) UK and (iii) France death outline as per China and S. Korea



(i) As per China's trend (ii) As per South Korea's trend

Fig. 6: Forecast India's death trend as per (i) China and (ii) South Korea trend.

forecasted trends if the countries follow China and S. Korea trends. As per the result, China and S. Korea took nearly 5 months to flatten the curve or to reduce the number of deceased. This shows that the effect of the wide spectrum of lockdown and social distancing measures implemented by the Chinese and South Korean governments could probably have contributed to stabilize the epidemic. The forecasted results depict that the USA, UK, and France will nearly take another 2 months to flatten the curve in terms of death cases. The proposed neutral network curve fitting model presents the forecast of the number of deaths. When the curve will start flattening, deaths may be approximately 134473 and 97272 for the USA as per China and S. Korea curves as on 24th June 2020 and 30th May 2020 respectively. Similarly, for the UK, 46370 as of 10th June 2020 and 34998 on 20th May 2020 as per the trends of China and S. Korea respectively. France may have 53326 death cases on 6th July 2020 and 39080 on 2nd June 2020, these numbers were forecasted as per China and Korea curve trends respectively.

The result shows that if the countries follow the steps and precautions taken by people of South Korea the rising death cases will be lowered as compared to China.

Case: IV Analysis of forecasted death cases trend in India as per the trends of China and S. Korea

In this section, the rapid increase in the number of death cases in India is considered for the analysis. India reported its 1st death due to COVID 19 on 13th March 2020 and thereafter the rate of death is increasing day by day. As reported on 4th May 2020 India has more than 1400 death cases. India announced a complete lockdown on 24th March 2020 and also the Indian government imposed public restrictions in many places to control the spread of this epidemic. In the present study, three forecast models of death cases in India have been proposed following the present progressive trend of China and South Korea which have already succeeded in controlling the pandemic.

Fig. 6 shows the effect of India's trend of the curve in case of the number of rising death and comparison has been made with the curve trend of China and South Korea. Fig. 6(i) shows that if India will follow the measures and precautions taken by the people and government of China then it will take more than 130 days to flatten the curve. Three forecast models of India since 4th May 2020, based on China's growth curve pattern are discussed below:

(i) If India will follow the curve pattern of China then the forecasted curve shows that the death toll will rise to 3015 by 19th of July 2020 and will remain steady flatting the curve.

(ii) The forecast model of India after 1 week shows that the death toll will rise to 4000 by 10th August 2020 and hereafter the curve will remain unchanged.

(iii) If India had followed the pattern of China a week before then the forecast model predicted 2100 cases of death flattening the curve.

In the same way, a comprehensive forecast analysis has been discussed for India if it follows the curve pattern of S. Korea shown in Fig. 6(ii), also three forecast models have been proposed from May 4, 2020, and are discussed below.

(i) South Korea is one of the most successful countries to fight against this pandemic as on 4th May 2020 because they have only 252 deaths and 10801 confirmed cases reported. The plot shows that India will control the death after 10th June 2020 with 2142 deaths.

(ii) If the pattern of S. Korea is followed then the forecast model shows that in a week India may have a death toll of 2898 as on 20th June 2020, and the curve may get stable after this.

(iii) A better scenario was revealed, if India had followed measures taken by S. Korea a week before then the death toll could have been controlled within 30th May 2020 with 1638 number of cases.

From the proposed model, it has been observed that if India follows the curve pattern of China then the forecast model shows stabilityh after 10th August 2020, the death toll will be stable with 4000 cases and S. Korean forecast model shows the better figure with approximate 3000 death cases up to 20th June.

CONCLUSION

Both infected and death cases of COVID19 are shooting up in all the countries under study with more new cases every day. Hence, effective techniques are required to study and analyse the data trends of COVID-19 cases for timely control of ever expanding pandemic. Unlike conventional forecasting methods, the study presents a new method of intelligent based optimum curve fitting and forecasting for different non-linear models. Such forecasting technique can be employed in any available sets of data. Major advantage of such method is that it does not involve complex calculations and can be applied to any other countries to help controlling the COVID-19 cases based on the experiences or trends of any other countries that have almost control the cases. The ANN curve fitting technique provides accurate forecasting of the rising cases based on the positive non-linear trends of China and South Korea who have put the cases into minimum level by imposing proper measures. It can also be concluded that artificial neural networks can efficiently train any set of country's data trend based on the input training data set to forecast the future cases of some countries. As per the case study, the confirmed cases of India, USA, France and UK following the trend in the first week of May 2020, could be as high as about 1,60,000, 17,00,000, 1,50,000, 2,50,000 respectively with a maximum period of 10 months just before controlling the cases. With more strict measures, the same could be controlled within 2 to 3 months and cases could be limited to about 50,000, 12,00,000, 1,40,000 and 2,40,000 for India, USA, France and UK respectively. Whereas, the total death cases for these countries could be as high as about 4000 for India, 1,35,000 for USA, 55,000 for France, 47,000 for UK during the same period of study. With better control strategies, within a period of 2 to 3 months, these figures could be limited to 1600 for India, 1,00,000 for USA, 40,000 for France and 35,000 for UK. Accordingly, the forecasts of the number of days required to keep control of COVID19 cases are presented for US, France, UK and India to help countries fight against the disease. In order to achieve such level towards flattening the trends, these countries will require a smaller number of days as per forecast with China's trend and more days with steady progress is seen with that of South Korea's trend. Besides, it can also be concluded that, with China's trend, countries with larger number of cases could be better in lesser number of days with possibly more stringent measures. Whereas, South Korea's trend is slower and steady control which could be more effective in early stage with lower cases reported. All the conclusions are made as per the forecasts obtained as a result of the ANN technique applied. Though the data of cases used in the study is based on reliable sources, the forecasts are as per the conditions and technique applied.

AUTHOR CONTRIBUTIONS

S.K. Tamang has reviewed COVID-19 related literatures, designed and developed the forecast model using ANN, generated and analysed graphs, prepared and edited the manuscript text. P.D. Singh's contribution invloves collection of COVID 19

data, compilation of data, generation and analysis of graphs and manuscript preparation and revision. B. Datta has contributed his input in the literatura review prcoess and manuscript preparation. All the authors contribute altogether in formulation of the objectives of the case study.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

ABBREVIATIONS

ANN	Artificial neural network
Covid-19	Coronavirus
ICTV	International Committee on Taxonomy of Viruses
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
WHO	World Health Organization
RNA	Ribonucleic Acid
ALI	Lung injury
MERS-CoV	Middle East respiratory syndrome coronavirus
ARDS	Acute respiratory distress syndrome
PIBA	Patient Information based Algorithm
SEIR	Susceptible Exposed Infectious Recovered
ARIMA	Autoregressive integrated moving average
LSTM	Long short-term memory

REFERENCES

Ahmadi, A.; Shirani, M.; Rahmani, F., (2020). Modeling and Forecasting Trend of COVID-19 Epidemic in Iran until May 13, 2020. MedRxiv **(19 pages).**

Bastos, S.; Cajueiro, Daniel., (2020). Modeling and forecasting the Covid-19 pandemic in Brazil. arXiv preprint arXiv:2003.14288 **(15 pages)**.

Barmparis, G.D.; Tsironis, G.P., (2020). Estimating the infection horizon of COVID-19 in eight countries with a data-driven approach. Chaos, Solitons & Fractals. 135:1-5 **(5 pages)**.

Benjamin, M.; Brockmann, D., (2020). Effective containment explains sub-exponential growth in confirmed cases of recent COVID-19 outbreak in Mainland China. arXiv:2002.07572v1 **(9 pages)**.

Benjamin, F.M.; Brockmann, D., (2020). Effective containment explains sub exponential growth in recent confirmed COVID-19 cases in China. Science. 368:742-746.

Chakraborty, T.; Ghosh, I., (2020). Real-time forecasts and risk assessment of novel coronavirus (COVID-19) cases: A data-driven analysis. Chaos, Solitons and Fractals. 135:1-10 **(10 pages).**

Chintalapudi, N.; Battineni, G.; Amenta, F., (2020). COVID-19 virus outbreak forecasting of registered and recovered cases after sixty-day lockdown in Italy: A data driven model approach. Journal of Microbiology, Immunology and Infection. In press **(8 pages)**.

Duccio, F.; Piazza, F., (2020). Analysis and forecast of COVID-19 spreading in China, Italy and France. Chaos, Solitons & Fractals. 134: 1-5 **(5 pages).**

Faïçal, N.; Iván, A.; Juan, J. N.; Torres, F.M., (2020). Mathematical modelling of COVID-19 transmission dynamics with a case study of Wuhan. Chaos, Solitons & Fractals. 135: 1-6 **(6 pages)**.

Gupta, S.; Singh, G.; Raghuwanshi, A. C., (2020). Effect of weather on COVID-19 spread in the US: A prediction model for India in 2020. Sci. Total Environ., 728(1): 1-8 **(8 pages).**

Haytham, E.; Hassanien, A., (2020). Day Level Forecasting for Coronavirus Disease (COVID-19) Spread: Analysis, Modeling and Recommendations. arXiv:2003.07778 **(19 pages)**.

Isaifan, R.J., (2020). The dramatic impact of Coronavirus outbreak on air quality: Has it saved as much as it has killed so far? Global J. Environ. Sci. Manage. 6(3): 275-288 **(14 pages)**.

Ivorra, B.; Ruiz, F.; Miriam, V.; María, A.M., (2020). Mathematical modeling of the spread of the coronavirus disease 2019 (COVID-19) taking into account the undetected infections. The case of China. Commun Nonlinear Sci Numer Simul. 88: 1-21 **(21 pages).**

Jing, Li.; Wang, L.; and Guo, S., (2020). Real-time estimation and prediction of mortality caused by COVID-19 with patient information based algorithm. Sci. Total Environ., 727: 1-9 **(9 pages).**

Kang, D.; Choia, H.; Kim, J. H.; Choi, J., (2020). Spatial epidemic dynamics of the COVID-19 outbreak in China. Int. J. Infect. Diseases. 94: 96 – 102 **(7 pages)**.

Kimberlyn, R.; Lee, Y.; Luo, R.; Kirpich, A.; Rothenberg, R.; Hyman, J.M.; Yan, P.; Chowell, G.,

(2020). Short-term Forecasts of the COVID-19 Epidemic in Guangdong and Zhejiang, China: February 13-23, 2020. J. Clin. Med. 9: 596-605 **(10 pages)**.

Linh Quach, H.; Hoang, N.A., (2020). COVID-19 in Vietnam: A lesson of pre-preparation. J. Clinical Virology. 127: 1 – 3 **(3 pages)**.

Liu, L., (2020). Emerging study on the transmission of the Novel Coronavirus (COVID-19) from urban perspective: Evidence from China. Cities. 103: 1-11 **(11 pages)**.

Matheus, H.; Ramon, S.; Viviana, C. M.; Leandro, S., (2020).

Short-term forecasting COVID-19 cumulative confirmed cases: Perspectives for Brazil. Chaos, Solitons and Fractals. 135: 1-10 **(10 pages).**

Nicola, M.A.P., (2020). COVID-19 and pets: When pandemic meets panic. Forensic Sci. Int. Rep. 2: 1-4 **(4 pages)**.

Peng, L.; Yang, W.; Zhang, D.; Zhuge, C.; Hong, L., (2020). Epidemic analysis of COVID-19 in China by dynamical modeling. Other Quantitative Biology. Cornell University, eprint 2002.07165 **(18 pages)**.

Petropoulos, F.; Makridakis, S., (2020). Forecasting the novel coronavirus COVID-19. PLOS ONE. 15. e0231236. **(8 pages).**

Singh, R.K.; Rani, M.; Bhagavathula, A.S.; Sah, R.; Rodriguez-Morales, A.J.; Kalita, H.; Nanda, C.; Sharma, S.; Sharma, Y.D.; Rabaan, A.A.; Rahmani, J.; Kumar, P., (2020). Prediction of the COVID-19 Pandemic for the Top 15 Affected Countries: Advanced Autoregressive Integrated Moving Average (ARIMA) Model JMIR Public Health Surveill. 6(2):1-10 **(10 pages).**

Tomar, A.; Gupta, N., (2020). Prediction for the spread of COVID-19 in India and effectiveness of preventive measures. Sci. Total Environ., 728 (1): 1-6 **(6 pages).**

WHO, (2020). Coronavirus disease (COVID-2019) press briefings.

Wang, J.; Tang, K.; Feng, K.; Weifeng, L., (2020). High temperature and high humidity reduce the transmission of COVID-19. Wang, Jingyuan and Tang, Ke and Feng, Kai and Lv, Weifeng, High Temperature and High Humidity Reduce the Transmission of COVID-19 (March 9, 2020). SSRN **(26 pages).**

Wang, Y.; Wang, Y.; Chen, Y.; Qin, Q., (2020). Unique epidemiological and clinical features of the emerging 2019 novel coronavirus pneumonia (COVID-19) implicate special control measures. J. Med. Virol., 92(6): 568-576 **(9 pages).**

Yuan, J.; Yun, H.; Lan, W.; Wang, W.; Sullivan, S.G.; Jia, S., (2006). A climatologic investigation of the SARS-CoV outbreak in Beijing, China. Am. J. Infect. Control. 34(4): 234–236 **(3 pages)**.

Zhao, Z.; Zhang, F.; Xu, M.; Huang, K.; Zhong, W.; Cai, W.; Yin, Z.; Huang, S.; Deng, Z.; Wei, M.; Xiong, J.; Hawkey, P.M., (2003). Description and clinical treatment of an early outbreak of severe acute respiratory syndrome (SARS) in Guangzhou, PR China. J. Med. Microbiol., 56: 715–720 **(6 pages).**

Zhao, Z.; Xin, Li.; Feng, L.; Zhu, G.; Wang, L., (2020). Prediction of the COVID-19 spread in African countries and implications for prevention and control: A case study in South Africa, Egypt, Algeria, Nigeria, Senegal and Kenya, Sci. Total Environ. 729(10):1-10 **(10 pages).**

Zixin, H.; Qiyang, G.; Shudi, Li.; Li, J.; Momiao, X., (2020). Artificial Intelligence Forecasting of Covid-19 in China. Other Quantitative Biology. Cornell University, eprint 2002.07112 **(14 pages)**.

Zhu, N.; Zhang, D.; Wang, W.; Li, X.; Yang, B.; Song, J., (2019). A novel coronavirus from patients with pneumonia in China. N. Engl. J. Med. 382:727-733 **(7 pages)**.

Zu, Z.Y.; Jiang, M.D.; Xu, P.P.; Chen, W.; Ni, Q.Q.; Lu, G.M., (2020). Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology (inpress) **(29 pages)**.

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