European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 11, 2020

Simple Forecasting Model for COVID-19 Cases in India - Multilevel Model Evaluation with R^2, MSE, and MAE

[1]Pasam Prudhvi Kiran, [2]E.Laxmi Lydia, [3]N.Sharmili, [4]Ravuri Daniel,[5]Dr.A.Krishna Mohan

[1]Department of Information Technology, Vignan's Institute of Information Technology, India.
[2]Professor, Department of Computer Science and Engineering, Vignan's Institute of Information Technology (A), Visakhapatnam (Andhra Pradesh), India,
3Associate Professor, Computer science and Engineering Department, Gayatri Vidya Parishad College of Engineering for Women, Visakhapatnam, Andhra Pradesh, India,
[4]Department of Computer Science and Engineering, Bapatla Engineering College, India
[5]Professor, Department of Computer Science and Engineering, JNTUK, Andhra Pradesh, India

Abstract

All-inclusive, more than 20 million individuals have been infected with the COVID-19, with the most number of cases from the United States, trailed by Brazil and India. In perspective on this developing extent of the number of cases, forecasting models are exceptionally useful to be prepared to confront the pandemic circumstance. In this work, we have used an efficient time series based Machine Learning (ML) algorithm to forecast the COVID-19 cases in India. We have trained the system with data from 3 March 2020 to 7 August 2020 and we have forecasted the values from 8 August 2020 to 9 September 2020. We have seen that the total no. of cases will get doubled, i.e. reaches 40 Lakhs by the end of the forecasted period. Along with this forecast we have done the multi-level validation of our work using metrics, r-squared error (R^2), mean squared error (MSE), mean absolute error (MAE).

Keywords

COVID-19, Machine Learning (ML), Time Series, Forecasting, Model Evaluation

1. Introduction

Coronavirus disease (COVID-19) is an irresistible sickness brought about by a newfound coronavirus. A great many people who fall sick with COVID-19 will encounter symptoms ranging from gentle to moderate and may come out of this infection without special clinical attention. [1]. With a record single-day increment of 66,999 cases, India's COVID-19 count mounted to 23,96,637 today, i.e. August 13, 2020, while the number of patients who have recouped from the illness flooded to 16,95,982, pushing the recuperation rate to 70.77 percent in the nation, as per the Union health ministry [2]. The loss of life due to COVID-19 moved to 47,033 with 942 individuals surrendering to the infection over the most recent 24 hours, as per health ministry information refreshed at 13 August 8 am [3,4]. India crossed the 20-lakh mark as far as COVID-19 cases on August 7 [4].

WHO has recognized that the hard work and caring assistance gave by India's health laborers, including medical caretakers, have contributed a lot to the nation's noteworthy recovery rate [5]. In a progression of profiles, medical attendants depicted their difficulties in protecting their charges and themselves on a COVID-19 repatriation flight, in clinics and ICUs, giving antenatal consideration, older consideration and psychosocial support with regards to COVID-19, and, for one medical attendant, of being isolated for about fourteen days in the wake of thinking about patients who tried positive for the infection. Medical caretakers are being prepared to manage COVID-19 patients, guarantee that conventions are followed, use PPE appropriately, and practice hand cleanliness, in addition to other things. On other hand Trained Nurses Association of India, the biggest nursing

relationship in the nation, delivered information just because since the start of the pandemic, showing that 509 nursing staff were contaminated and 20 lost their lives while giving treatment to COVID patients [6]. Maharashtra, Gujarat, and West Bengal have the most extreme number of COVID positive staff medical caretakers in the nation and the most noteworthy casualty rate. Near 200 specialists, most of them general experts have lost their lives to COVID-19 till August 7 as indicated by data assembled and delivered by the Indian Medical Association (IMA). The country has not yet arrived at any pinnacle or level as far as coronavirus cases which implies the circumstance is on its way to worst, advised CSIR-Center for Cellular and Molecular Biology (CCMB) [7,8].

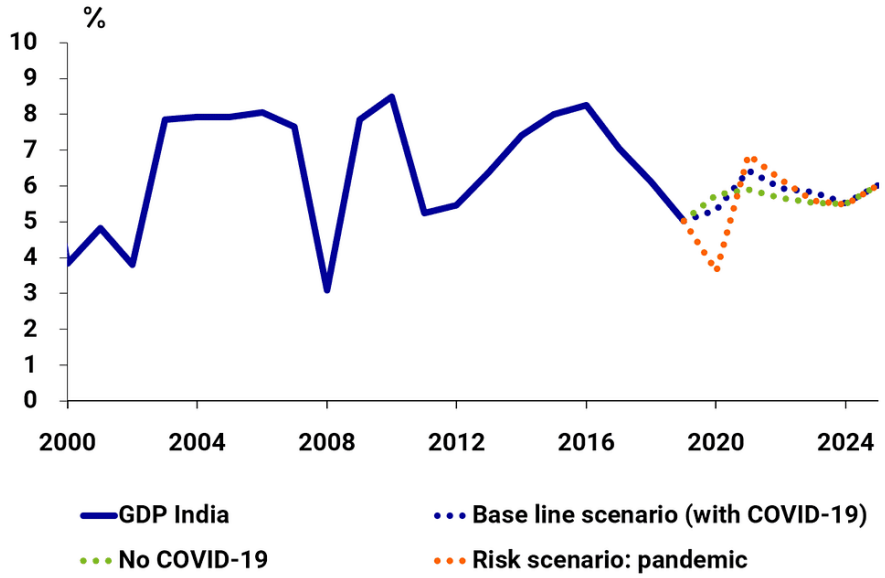

Figure 1 - Impact on GDP due to COVID-19 crisis (Source - bloombergquint.com [9])

India's financial action screens are starting to flatline only months in the wake of giving indications of coming back to life [10]. Most recent information from Apple Inc. what's more, Alphabet Inc's. Google demonstrated portability endured as of late in the wake of scoring up an expansion since May when Asia's third-biggest economy started leaving an across the nation lockdown to contain the coronavirus episode [11]. Somewhere else, high-recurrence markers from buying troughs' reviews to fuel deals show development leveling in July. Also, that is not all. Duty assortment has been directed, while a proportion of between state development of merchandise traffic by street and rail has demonstrated little change [11,12]. Information from private examination firm, Center for Monitoring India Economy Pvt., shows joblessness rising marginally after some improvement in June and July [13]. The drop in action might be legitimately connected to India's endeavors to battle the infection flare-up. The country, which is including more than 50,000 cases day by day, is seeing a portion of its most-industrialized states reimposing lockdowns to stop the spread of Covid-19. India's exit from the lockdown isn't aligned. The nation has been depending on spontaneous lockdowns that may be going about as a limitation on the food of financial action. The economy is now set out toward its most noticeably awful droop in over four decades, with the International Monetary Fund assessing the country's total national output will contract 4.5 percent this year [14].

1.1. The Vaccine Milestone

Scientists overall are working nonstop to discover an immunization against SARS-CoV-2, the infection causing the COVID-19 pandemic. Specialists think that an optimized antibody improvement procedure could speed an effective contender to showcase in around 12 to 18 months if the procedure goes easily from origination to advertise accessibility [15]. Until this point, only one coronavirus antibody has been endorsed. Sputnik V - once in the past known as Gam-COVID-Vac and created by the Gamaleya Research Institute in Moscow - was endorsed by the Ministry of Health of the Russian

Federation on 11 August. Specialists have raised extensive worry about the immunization's security and adequacy given it has not yet entered Phase 3 clinical preliminaries [16]. The pandemic has made exceptional open/private organizations. Operation Warp Speed (OWS) is a coordinated effort of a few US national government offices including Health and Human Services and its sub-agencies, Agriculture, Energy, and Veterans Affairs and the private area [17]. Inside OWS, the US National Institutes of Health (NIH) has cooperated with more than 18 biopharmaceutical organizations to quicken the advancement of medication and antibody possibility for COVID-19 (ACTIV). The COVID-19 Prevention Trials Network (COVPN) has likewise been built up, which joins clinical preliminary systems subsidized by the National Institute of Allergy and Infectious Diseases (NIAID): the HIV Vaccine Trials Network (HVTN), HIV Prevention Trials Network (HPTN), Infectious Diseases Clinical Research Consortium (IDCRC), and the AIDS Clinical Trials Group. The US government has picked three antibody possibilities to finance for Phase 3 preliminaries under Operation Warp Speed: Moderna's mRNA-1273, The University of Oxford and AstraZeneca's AZD1222, and Pfizer and BioNTech's BNT162. Individuals from ACTIV have recommended creating safe controlled human contamination models (CHIMs) for human preliminaries that could take 1-2 years. Support would need to give information from fake treatment controlled preliminaries demonstrating their immunization is at any rate half-successful against COVID-19 to be approved for use, as indicated by FDA direction gave and compelling 30 June. This tracker records COVID-19 antibody applicants as of now in Phase 1-3 preliminaries, just as significant competitors in pre-clinical phases of improvement and examination [15,17].

2. Artificial Intelligence (AI) is a Vital Player

Without a doubt, AI is doing a crucial job in this pandemic circumstance, contributing a great deal in early discovery and diagnosing of the contamination [18]. Computer-based intelligence can rapidly investigate doubtful indications and other 'warnings' and along these lines caution the patients and the medicinal services specialists. It assists in giving a quicker dynamic, which is practical. It assists with building up another determination and the executives framework for the COVID 19 cases, through valuable calculations [19]. Particularly when we talk about the projection of cases and related information, this innovation can track and conjecture the idea of the infection from the accessible information, web-based life, and media stages, about the dangers of the disease and its presumable spread. Further, it can foresee the number of positive cases and pass in any locale. Computer-based intelligence can help recognize the weakest areas, individuals, and nations and take quantify appropriately [20]. With the assistance of constant information examination, AI can give refreshed data which is useful in the counteraction of this illness. It very well may be utilized to foresee the likely locales of contamination, the inundation of the infection, requirement for beds, and social insurance experts during this emergency [21,22]. Simulated intelligence is useful for future infection and maladies counteraction, with the assistance of past coached information over information predominant at various times. It distinguishes attributes, causes, and explanations behind the spread of contamination. In the future, this will end up being a significant innovation to battle against different plagues and pandemics. It can give a preventive measure and battle against numerous different illnesses. In the future, AI will assume a crucial job in giving more prescient and preventive human services. Computerized reasoning is an up and coming and valuable device to distinguish early contaminations due to coronavirus and helps in observing the state of the tainted patients [19,23]. It can fundamentally improve treatment consistency and dynamic by creating valuable calculations. Computer-based intelligence isn't just useful in the treatment of COVID-19 contaminated patients yet also for their appropriate wellbeing observing. It can follow the emergency of COVID-19 at various scales, for example, clinical, sub-atomic, and epidemiological applications. It is additionally useful to encourage the exploration of this infection utilizing investigating accessible information. Simulated intelligence can help in creating legitimate treatment regimens, counteraction systems, and medication and immunization improvement.

The further paper contains methodology in section 3 and section 4 contains respective results and finally, section 5 is the conclusion.

3. Proposed Methodology

Figure 2 illustrates the flow of this paper. It shows various theoretical and mathematical modules presented in Section 3 and the visualization of results in Section 4.

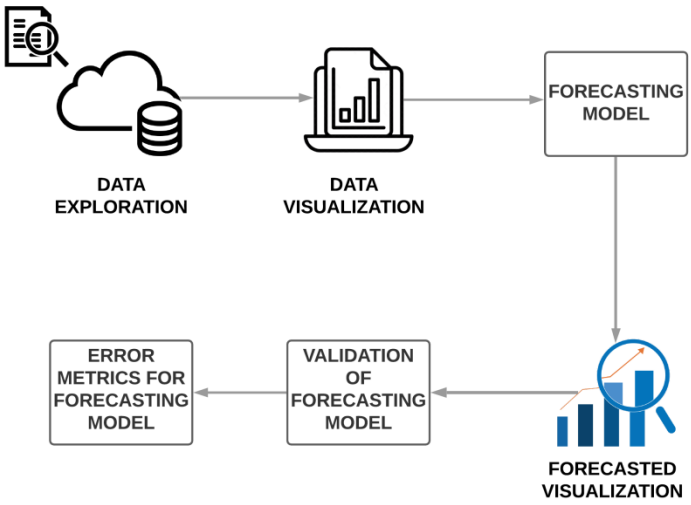

Figure 2 - Process flow of the proposed methodology

I. Data Exploration

This is the primary step that should be done with utmost clarity. A lot of data should be explored once after deciding what to forecast and what type of forecasting model, we are willing to use. There exist a lot of valid data sources nowadays, thanks to ourworldindata.org, for enabling the users to download correct and updated data about Covid-19 spread across the world (Dataset Link - https://covid.ourworldindata.org/data/owid-covid-data.xlsx). The available dataset contains all country's data with important parameters such as, total no. of cases, daily new cases, and total no. of deaths, total no. of new deaths, and many other parameters, which may stand useful for different research paths. In this dataset, we have taken the daily rise of new cases and total no. of cases in India, concerning the date from January 31 to August 7, 2020. Along with the collection of data, data exploration also facilitates data pre-processing, wherein this step we will go through the entire data and have a look at it and double-check whether there are any data missing columns left. And also we have to make sure that the data is appropriate for our work objective. Our pre-processing results; although the first COVID-19 case is recorded in India on 31 January 2020, there is no consequent rise in number till 3 March 2020, so we cropped our dataset to 3 March 2020, as a first column and ends at 7 August 2020. It makes a total of 157 rows and 3 columns, i.e. date, no. of new cases, and total no. of cases.

II. Data Visualization

Before jumping into the forecasting part, we have visualized the available dataset, using a plotting library called Matplotlib through Python programming language. Figure 2 and Figure 3 in the results section illustrate, line plot of the total no. of cases and daily new cases in India from March 3 2020 to August 7, 2020. Data visualization is always a good step to understand our data and it also provides very useful insights.

III. Forecasting Model

In this step, we feed the model with our dataset. We use a time series forecasting model called Facebook Prophet, and the results section clearly shows it is the best suitable model for time series forecasting with a dataset like ours. The prophet is a technique for forecasting time series information reliant on an additional substance model where patterns that are non-straight are fit with yearly, week

after week, and everyday abnormality, in addition to event impacts. It works best with a time game plan that has strong intermittent effects and a couple of times of genuine data. The prophet is solid to missing data and developments in the example, and regularly handles exemptions, called outliers, well. The prophet is open-source programming conveyed by Facebook's Core Data Science team. It is available for download on CRAN and PyPI, i.e. it will work on both R and python. The prophet is used in various applications across Facebook for conveying dependable conjectures for the target setting. It performs better than some other system in a large portion of cases and it empowers conjectures in just a few minutes. Like summed up added substance model (GAM), with time as a regressor, Prophet fits a couple of straight and non-direct components of time as portions, as appeared in condition 3.1 [24].

$$y(t) = g(t) + s(t) + h(t) + e(t) \quad (3.1)$$

where:
g(t) - design models non-discontinuous changes
s(t) - anomaly presents discontinuous changes
h(t) - ties in effects of events
e(t) - covers unusual changes not accommodated by the model

Prophet gives the forecasted values as yhat, yhat_lower and yhat_upper. Where yhat is the forecasted value direct and yhat_lower is the lower possibility of yhat and yhat_upper is the upper possibility of yhat, i.e. the maximum and minimum thresholds of yhat. Prophet forecast visualization also contains these thresholds also, where a dark blue line is yhat and it's lower and upper shaded borders are yhat_lower and yhat_upper. And the black dots are the actual values. This is the beauty of the prophet where we can get the basic idea of how efficient the model is, just by looking at the forecasted plot.

IV. Forecasted Visualization

After fitting the data into Prophet, we are ready to forecast the desired amount of future values. By training the system with data of daily new cases from 3 March 2020 to 7 August 2020, we forecasted the daily no. of new cases recorded every day from 8 August 2020 to 9 September 2020. Figure 4 in the results section shows the plot which visualizes the daily new cases from March 3 to September 9 that includes the actual dataset and forecasted data. Figure 5 from the results section represents the total no. of cases raise till September 9, 2020, and it says that the total no. of cases reaches the 40 Lakhs mark by 9 September 2020. These forecasted visualizations met half the objective of this paper. Table 1 shows the forecasted values yhat along with yhat_lower and yhat_upper.

V. Validation of Forecasting Model

It is always very important to validate the model. We have validated the model in two cases. Case 1 validates with the testing dataset which is already a part of the training dataset. And Case 2 is the validation with the test dataset different from the trained dataset, i.e. the model did not know about this data. In both the cases, the forecasted values are compared with original values, where yhat is the forecasted value mentioned along with its lower and upper thresholds and y is the actual value. Figure 6, Figure 7, Table 2, and Table 4 shows the corresponding above-mentioned validation through comparison.

VI. Error Metrics for Forecasting Model

Model validation we have done above is consistently a decent practice to quantify the model precision. Along with that step we also calculate few error metrics; for our proposed model, R-Squared Error (R^2), Mean Squared Error (MSE), Mean Absolute Error (MAE), which are popular error metrics for many Machine Learning models, ranging from simple to complex. All these errors are calculated in between y and yhat, i.e. actual and forecasted. As an extension, we have calculated

for yhat_lower and yhat_upper also. Table 3 and Table 5 shows the error metrics of both cases validation. Having a look at mathematical equations will give a functional overview.

VII. R-Squared Error (R^2)

After a model is constructed, it is important to look at the legitimacy of the model. An underlying conclusion includes considering the estimations of the model with the purposes of the plan of tests. This is the situation for modification. To do such, some measures can be utilized to test the fit between the perceptions and forecasts on the information utilized for the development of the model. This is quite the job of the assurance of coefficients R^2 [25].

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{\sum_{i=1}^{n} (y_i - \overline{y})^2} \quad (3.2)$$

y - estimation of the normal reaction
n - number of points in the plan of tests

The determination coefficient is the standard usually used in the linear regression to test the difference in the model. This coefficient is portrayed in equation 3.2. This measurement gives a sign of how great a model fits a given dataset. It shows how close the forecast is to the real information esteems. The R squared worth lies somewhere in the range of 0 and 1 where 0 shows that this model doesn't fit the given information and 1 demonstrates that the model fits very well to the dataset given.

VIII. Mean Squared Error (MSE)

MSE is determined by taking the normal of the square of the contrast between the original and forecasted estimations of the information [25]. MSE means the proportion of the square of the two standards of the mistake vector to the number of tests and is characterized as appeared in 3.3.

$$MSE = \frac{1}{m} \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \quad (3.3)$$

m - number of components of information from the entire test process.

This standard estimates the mean square error submitted in the test information. A low MSE esteem implies that the forecasted qualities are near to original values.

IX. Mean Absolute Error (MAE)

$$MAE = \frac{1}{m} \sum_{i=1}^{m} |y_i - \hat{y}_i| \quad (3.4)$$

We realize that an error fundamentally is the contrast between the actual and the forecasted. The absolute difference implies that if the outcome has a negative sign, it is ignored. Henceforth, MAE = True values – Predicted values [25]. MAE takes the average of this mistake from each sample in a dataset and gives the resulting output. Contrasted with the other two measurements, it is more vigorous since it is less delicate to outrageous qualities than MSE. MAE gives the normal extent of forecasted blunders, while MSE gives more weight to the biggest mistakes. MAE spoke to in condition 3.4. It isn't exceptionally touchy to anomalies in contrast with MSE since it doesn't rebuff tremendous blunders.

4. Forecasting and Model Evaluation

I. 4.1 Dataset Visualization

As already mentioned our dataset consists of 157 rows, i.e. data representation of 157 days from 03 March 2020 to 07 March 2020. And there are three columns, where Date is the first one, Daily new cases are second, and Total no. of cases is third. Figure 3 and Figure 4 show the visual representation of our dataset.

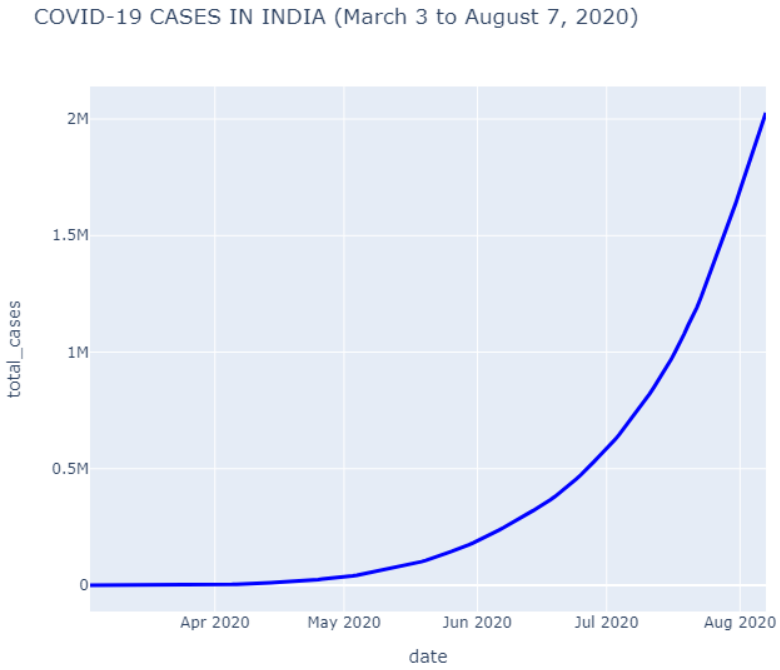

Figure 3 - Total Cases in India - March 3 to August 7

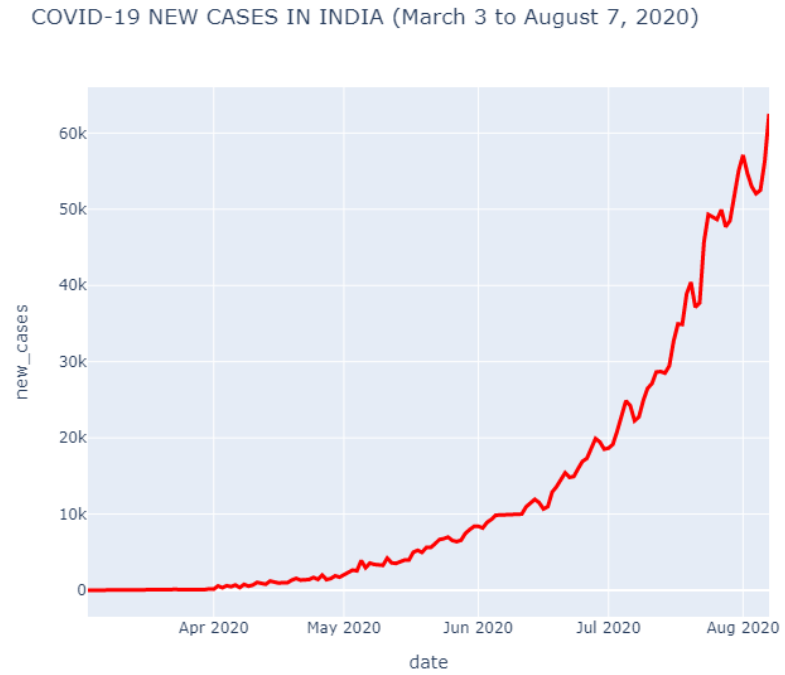

Figure 4 - Daily New Cases in India - March 3 to August 7

II. Forecast

Now we have given the entire dataset to the prophet model and made a forecast for the next 30 days, i.e. from 08 August 2020 to 09 September 2020. The objective here is to forecast to the daily rise of new cases for the targeted period. The forecasted plot is shown in Figure 5 and the forecasted values

are represented in Table 1. You can observe yhat, yhat_lower, and yhat_upper in the table, where lower and upper are the possible lower and higher threshold values for the forecasted value yhat.

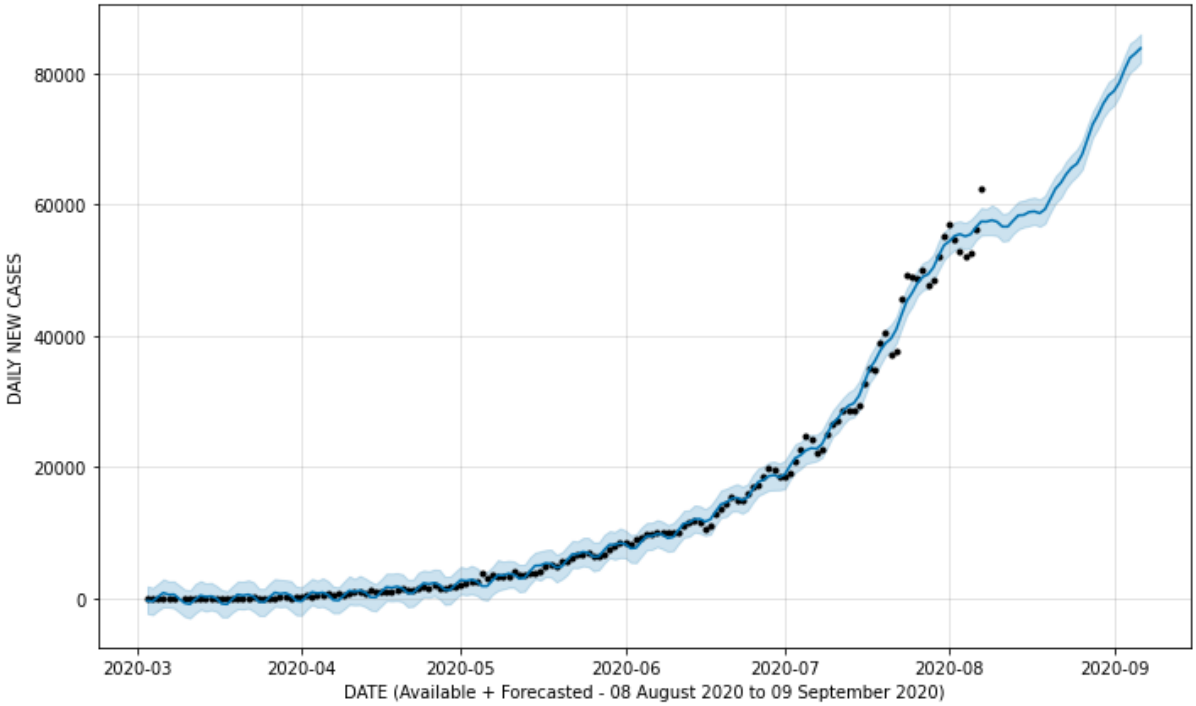

Figure 5 - Daily New Cases from March 3 to September 09, 2020 (Forecasted - August 8 to September 9)

Table 1 - Forecasted Values from Figure 5 - Daily new cases; August 8 to September 9 2020

S.No	Date	yhat	yhat_lower	yhat_upper
1	2020-08-08	57403	55402	59384
2	2020-08-09	57638	55396	59905
3	2020-08-10	57388	55250	59446
4	2020-08-11	56650	54422	58596
5	2020-08-12	56647	54543	58765
6	2020-08-13	57539	55552	59651
7	2020-08-14	58372	56273	60490
8	2020-08-15	58424	56590	60659
9	2020-08-16	58873	56765	60958
10	2020-08-17	58966	56998	61101
11	2020-08-18	58697	56673	60818
12	2020-08-19	59275	57142	61407
13	2020-08-20	60849	58821	62975
14	2020-08-21	62447	60274	64402
15	2020-08-22	63327	61065	65270
16	2020-08-23	64643	62533	66635
17	2020-08-24	65620	63572	67602
18	2020-08-25	66221	64333	68427
19	2020-08-26	67632	65359	69803
20	2020-08-27	69974	67779	72091

21	2020-08-28	72246	70268	74231
22	2020-08-29	73681	71625	75695
23	2020-08-30	75412	73318	77339
24	2020-08-31	76640	74448	78751
25	2020-09-01	77312	75150	79344
26	2020-09-02	78600	76555	80634
27	2020-09-03	80615	78551	82700
28	2020-09-04	82353	80122	84601
29	2020-09-05	83047	80808	85170
30	2020-09-06	83834	81692	86003

Adding the above-forecasted data to the presently available data, the model shows that the total no. of cases in India will cross the mark of 4 Million, by September 09, 2020. This increasing plot is visualized in Figure 6. You can also see the visualization facilitates, data with all three probabilities; y hat, yhat_lower, and yhat_upper.

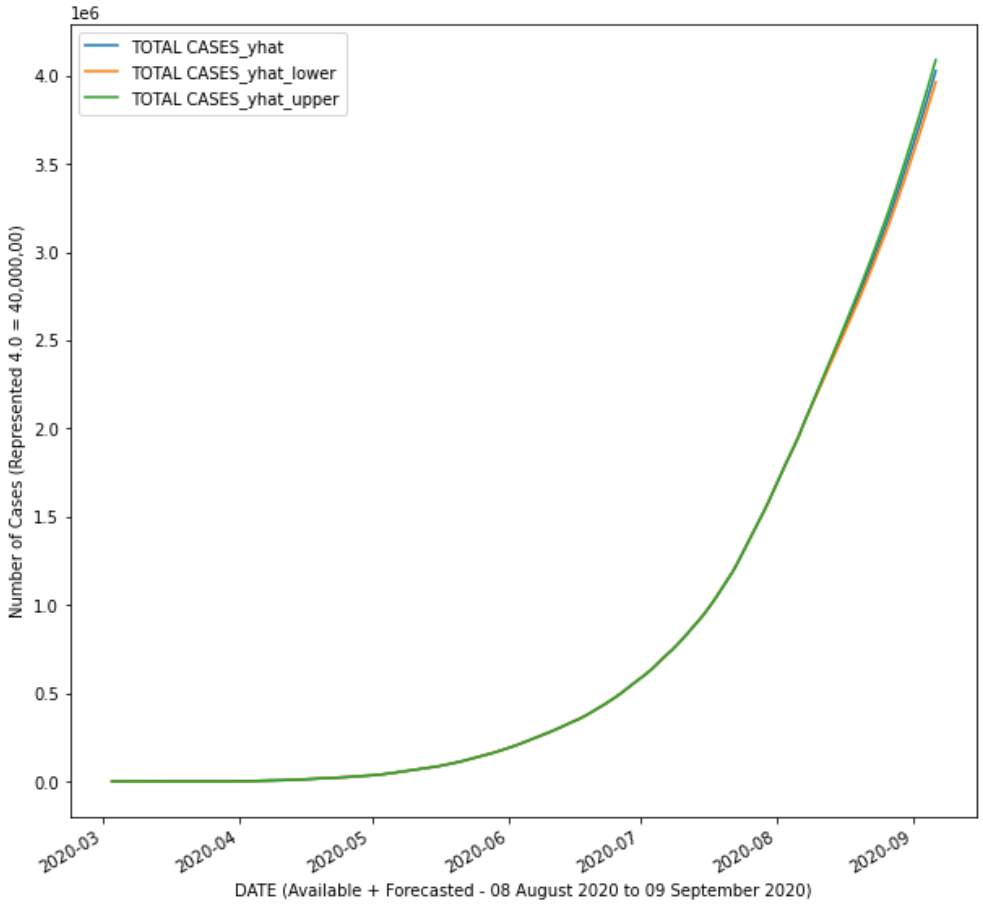

Figure 6 - Total no. of cases in India from March 3 to September 09 2020
(Forecasted - August 8 to September 9)

III. Model Evaluation and Error Metrics

Evaluation - Case 1 - Training and Testing with Same Data

Here, in this case, we are checking the accuracy of the built model with a test dataset, which is already the part of the training dataset. Figure 7 visualizes the forecast from 1 August 2020 to 7 August 2020 and respectively Table 2 gives the comparison between actual values and forecasted values.

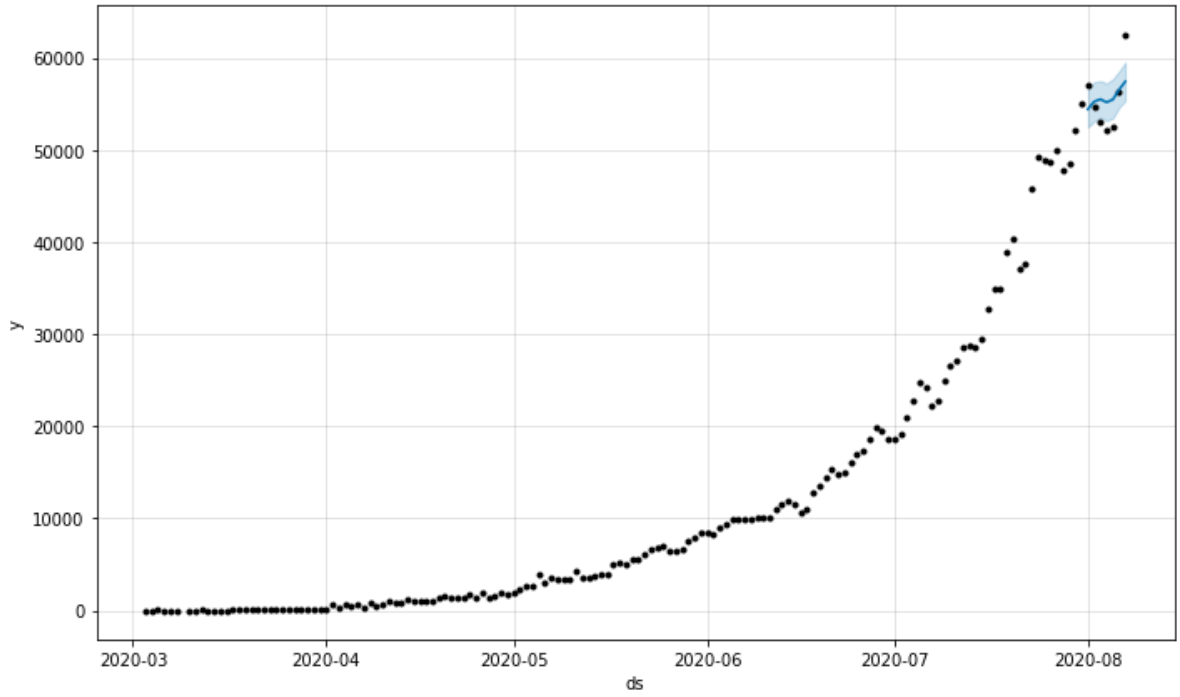

Figure 7 - Case 1 evaluation forecast

Y is the actual value with respective date and yhat is the predicted value followed by yhat_lower and yhat_upper, which represents the lower and upper threshold of the forecasted value. It is good that the comparison observes the close difference between actual and forecasted values.

Table 2 - Comparison of forecasted values from Figure 7 with the original values

Date	Y (Actual)	yhat	yhat_lower	yhat_upper
01-08-2020	57118	54427	52271	56544
02-08-2020	54735	55250	53095	57248
03-08-2020	52972	55506	53399	57598
04-08-2020	52050	55178	52954	57156
05-08-2020	52509	55474	53309	57456
06-08-2020	56282	56546	54520	58860
07-08-2020	62538	57431	55332	59400

Here comes the major part of the model evaluation, where error metrics mentioned in the Methodology section of this paper are calculated and tabulated in Table 3. We can also find a few negative values in the table.

Table 3 - Error metrics for Case 1 evaluation

Error Metric	yhat	yhat_lower	yhat_upper
R-squared error	0.272049132	-0.028280106	-0.180040146

Mean squared error	8379230.857	11836233.43	13583099.14
Mean absolute error	2457.714286	2512.285714	3354.571429

Evaluation - Case 2 - Training and Testing with Different Data

Evaluation and calculation of error metrics are done in the same manner as specified in Case 1. But the difference here is we are checking the accuracy of the built model with a test dataset, which is not part of the training dataset, i.e. we are training the system with data from 03 March 2020 to 31 July 2020 and we made the model forecast the values from 01 August 2020 to 7 August 2020. Figure 8, visualizes the discussed plot.

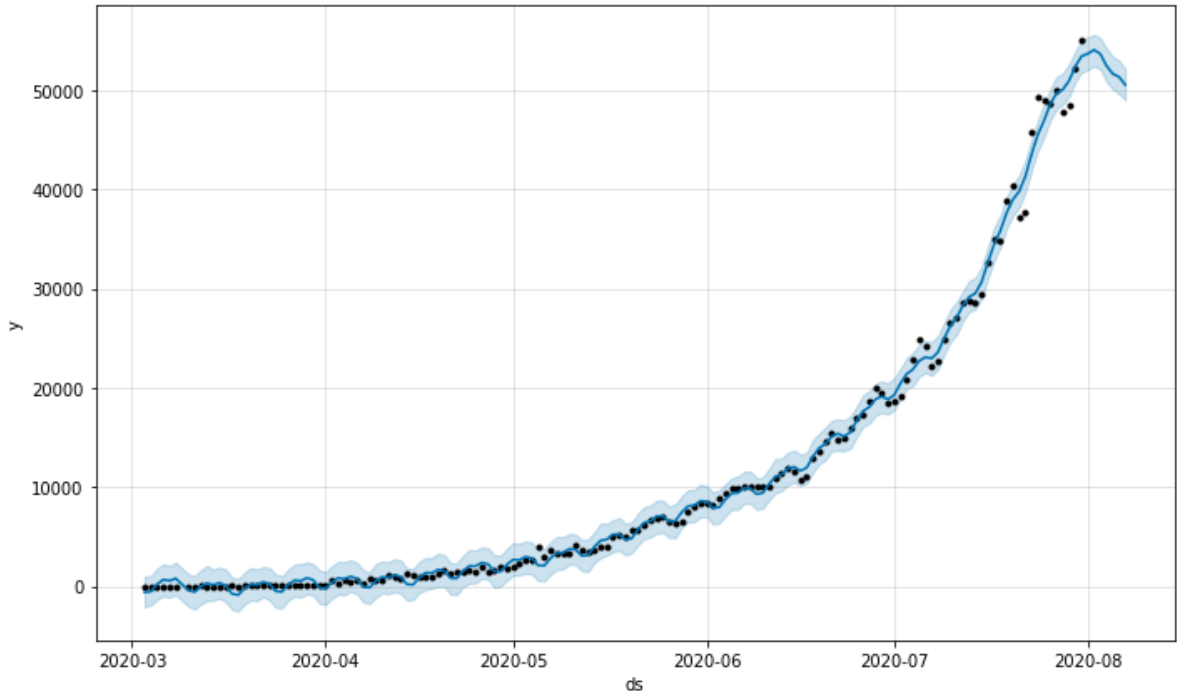

Figure 8 - Case 2 evaluation forecast

Table 4 - Comparison of forecasted values from Figure 8 with the original values

Date	y	yhat	yhat_lower	yhat_upper
01-08-2020	57118	53648	52014	55316
02-08-2020	54735	54024	52400	55579
03-08-2020	52972	53642	52075	55211
04-08-2020	52050	52427	50815	54212
05-08-2020	52509	51627	50065	53330
06-08-2020	56282	51312	49591	52980
07-08-2020	62538	50511	49000	52148

Table 5 - Error metrics for Case 2 evaluation

Error Metric	yhat	yhat_lower	yhat_upper
R-squared error	-1.274465797	-2.31438226	-0.649642942

Mean squared error	26180714.71	38150890.86	18988560.43
Mean absolute error	3301	4614.285714	3074.428571

5. Conclusion

The proposed work focuses on analyzing the adverse effect of COVID-19 on India and also proposed work showcases popular error metrics of the model. The forecast said that the cases will cross the 40 Lakh mark by the end of August 2020. This kind of forecast and the trend information presented is useful for everyone. On other hand, the ease of the Prophet Model will motivate the researchers to work on various aspects of this pandemic.

References

[1] Coronavirus, [Internet]. [Cited 2020 July 20]. Available from: https://www.who.int/health-topics/coronavirus
[2] Record single-day spike of 66,999 cases pushes India's COVID-19 tally to 23,96,637; death toll 47,033, [Internet]. [Cited 2020 July 20]. Available from: https://bit.ly/3iLvC9c
[3] Coronavirus in India: COVID-19 recovery rate rises to 70.77 pc, fatality rate declines to 1.96 pc, says health ministry, [Internet]. [Cited 2020 July 20]. Available from: https://bit.ly/31X8ePx
[4] With Biggest Single-day Jump of 66,999 Cases, India's Coronavirus Tally Nears 24 Lakh, [Internet]. [Cited 2020 July 20]. Available from: https://bit.ly/3atjBCM
[5] Caring for COVID-19 patients: Nurses across the country share their journey, [Internet]. [Cited 2020 July 23]. Available from: https://www.who.int/india/news/feature-stories/detail/caring-for-covid-19-patients-nurses-across-the-country-share-their-journey
[6] Coronavirus | 20 trained nurses dead, 509 infected, says TNAI, [Internet]. [Cited 2020 July 23]. Available from: https://www.thehindu.com/news/national/coronavirus-20-trained-nurses-dead-509-infected-says-tnai/article32346557.ece
[7] Nation yet to reach COVID peak: CCMB, [Internet]. [Cited 2020 July 28]. Available from: https://bit.ly/2XXWCKX
[8] Coronavirus India lockdown Day 143 updates, [Internet]. [Cited 2020 July 30]. Available from: https://www.thehindu.com/news/national/coronavirus-india-lockdown-august-14-2020-live-updates/article32350728.ece
[9] Coronavirus: The Economic Impact of COVID-19 On India, [Internet]. [Cited 2020 July 29]. Available from: https://www.bloombergquint.com/opinion/coronavirus-the-economic-impact-of-covid-19-on-india
[10] Early signs of India economic recovery wane as coronavirus surges, [Internet]. [Cited 2020 July 29]. Available from: https://www.livemint.com/news/india/early-signs-of-india-economic-recovery-wane-as-coronavirus-surges-11597148963017.html
[11] Cases surge, [Internet]. [Cited 2020 July 29]. Available from: https://bit.ly/3iDqDaA
[12] India's economic recovery, [Internet]. [Cited 2020 July 30]. Available from: https://bit.ly/2EacuTl
[13] The economy is headed for worst slump in over four decades as IMF sees GDP shrink 4.5% this year, [Internet]. [Cited 2020 July 30]. Available from: https://bit.ly/30Wq8T2
[14] COVID-19 vaccine tracker, [Internet]. [Cited 2020 July 30]. Available from: https://www.raps.org/news-and-articles/news-articles/2020/3/covid-19-vaccine-tracker
[15] Russia's approval of a COVID-19 vaccine is less than meets the press release, [Internet]. [Cited 2020 July 30]. Available from: https://www.sciencemag.org/news/2020/08/russia-s-approval-covid-19-vaccine-less-meets-press-release
[16] Fact Sheet: Explaining Operation Warp Speed, [Internet]. [Cited 2020 July 30]. Available from: https://bit.ly/3fZTkNo
[17] The Truth about Vaccines: Part 2, [Internet]. [Cited 2020 July 30]. Available from: https://bit.ly/2DXUqMu

[18] Pasam PrudhviKiran, Dr. E. Laxmi Lydia,Dr.T. Pavani. (2020). SEIR Model for Tracking Covid-19 Outbreak. International Journal of Advanced Science and Technology, 29(7s), 4519 - 4526. Available from: http://sersc.org/journals/index.php/IJAST/article/view/25690
[19] Haleem A, Javaid M, Vaishya. Effects of COVID 19 pandemic in daily life. Curr Med Res Pract 2020. Available from: https://doi.org/10.1016/j.cmrp.2020.03.011.
[20] Bai HX, Hsieh B, Xiong Z, Halsey K, Choi JW, Tran TM, Pan I, Shi LB, Wang DC, Mei J, Jiang XL. Performance of radiologists in differentiating COVID-19 from viral pneumonia on chest CT. Radiology 2020. Available from: https://doi.org/10.1148/radiol.2020200823.
[21] Hu Z, Ge Q, Jin L, Xiong M. Artificial intelligence forecasting of COVID-19 in China. arXiv preprint arXiv:2002.07112. 2020 Feb 17.
[22] Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L. Correlation of chest CT and RT PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology 2020. Available from: https://doi.org/10.1148/
[23] Haleem A, Vaishya R, Javaid M, Khan IH. Artificial Intelligence (AI) applications in orthopaedics: an innovative technology to embrace. J Clin Orthop Trauma 2019. Available from: https://bit.ly/30ZwWPK
[24] The Math of Prophet, [Internet]. [Cited 2020 August 1]. Available from: https://bit.ly/2CxPAFg
[25] Mean Absolute Error, [Internet]. [Cited 2020 August 5]. Available from: https://bit.ly/2Y6wCNA