Application to Predict the Impact of COVID-19 in India Using Deep Learning

Kiran S. Raj and Priyanka Kumar

Abstract The COVID-19 pandemic has hit almost all the parts of the world. Originating in Wuhan, China, to spreading all across the world, it is safe to say now that the pandemic has shocked the people. Despite all the advancements in medicine and science, it is quite frankly a realization to the world that a virus can rip apart everyone's lives [1]. The USA, being the worst impacted by the same [2], countries like India are experiencing the growth of the virus rapidly. From social distancing to living with the virus, we humans are finding out different ways to survive this pandemic and return to normalcy. The importance of understanding the situation reels' core to the lives of everyone. In this chapter, we keep update about the change in events, cases reported, people deceased, people recovered, contact for essential service, the current status of the state/country is essential to provide a system that people could depend on during the time of the pandemic. This research works on the core principle of providing real-time information to the people, by supplementing it with the state-wise report, national reports, essential services, and contacts provided by the state. This chapter also explains the power of AI/ML which will predict how the cases would progress in the coming days. The model used details of a convolutional neural network to predict the spread of the pandemic, hence gives an idea of how the pandemic would spread with a close approximation to the real-world data.

Keywords Deep learning · Time series analysis · COVID-19 forecasting · CNN

1 Introduction

The COVID-19 pandemic has wrecked life in dimensions one cannot perceive. From its inception in Wuhan during December 2019, the virus has spread and affected

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most of the world. The part of the virus that scares most of the world has to deal with the fact of its ability to spread rapidly. The cases have grown ever since and a total of 952,000 deaths have been reported so far all around the world. The most arduous impact on the people has to do with the fact that lockdown had been imposed in most of the countries which eventually lead to unemployment, scarcity of food, a drop in the overall economy, and most importantly, a very sad time in everyone's life.

The most daring fact about humans revolves around the ability to be resilient and strike back even when the odds are against them. From time immemorial, humans have always overcome obstacles, found solutions, and have come out much stronger than ever before. The research work aims to provide awareness and the threat of COVID-19 among everyone. The application focuses on creating a system that provides the details of how the pandemic would spread in high accuracy, thereby making inferences and taking necessary precautions regarding the same. The saying, "Prevention is better than cure" has become an integral part of what we are currently facing and yet to face.

This work hopes to provide users without sufficient information regarding the pandemic, its spread, and also the contact of necessary resources to be taken during this pandemic. With this system intact, we are trying to create a mentality that would augment the wellbeing of the public by keeping in mind the disastrous effects of the pandemic. It has now reached a situation where scientists and other researchers are instilling the idea of living with the virus as the only way to progress forward, due to the time and other constraints that come to being while developing the vaccine. It is only right to stay updated about the pandemic and move forward with one's life. That is what humans have done since history, defy all the odds, and stop at nothing. With the system in check, government officials and other bodies can have a rough understanding of how the pandemic would spread [3] in the coming days and take necessary precautions to control the spread of the virus. The system can be used as a fundamental basis/blueprint for scripting out the necessary actions.

Our goal is to augment the wellbeing of the public, bring back the confidence among them by taking necessary precautions, and hence move on with life.

Roadmap. The chapter is organized as follows. The aim of the research work for the current pandemic is present in Sect. 2. In Sect. 3, we demonstrate our proposed modules. In Sect. 4, we detail the need for deep learning and the architecture used for the model. Section 5 describes the system implementations and Sect. 6 describes the results and analysis. Finally, the conclusion is presented in Sect. 7.

2 Proposed Work

Some recent works similar to the topic are detailed as COVID-19 trackers. There exist many trackers [4] providing the information on the count of the COVID-19 affected patients, recovered cases, and deceased cases. These works revolve around getting the information from the API and displaying it in a format that the user understands

[5]. Some of the work focuses on predicting the spread of the pandemic using the SIR model.

The proposed system is presented to the user in the form of a web application with Flask in the backend. The user is greeted with a home page detailing cards that have snippets of information regarding the daily impact of COVID-19 in India. These snippets include total number of cases on the current day, deaths on the current day, recovered cases on the current day, and active cases reported on the current day. These pieces of information are updated in real time and are up-to-date for the user to view. The cards are followed by graphical representations. There are four graphs as follows:

- Overview of COVID-19 cases in India (contains total cases, active cases, deaths, recovered cases—with date).
- Total cases of COVID-19 in India, which contains the graph of how the total cases in India are emerging, followed by an artificially intelligent prediction of how the cases will follow for the next 30 days.
- Active cases of COVID-19 in India, which contains the graph of how the active cases in India are emerging, followed by an artificially intelligent prediction of how the cases will progress for the next 30 days.
- Daily cases of COVID-19 confirmed in India, which contains the graph of how the daily confirmed cases in India are emerging, followed by an artificially intelligent prediction of how the cases will progress for the next 30 days.

Figure 1 illustrates the home page of the application. The user is presented with an info card detailing about the present number of cases, recovered cases, daily confirmed cases, and the deaths. This is followed by the visualization of the same where predictions are also incorporated within each of the graphs. This visualization gives a rough idea to the user regarding the spread of the pandemic in the upcoming days.

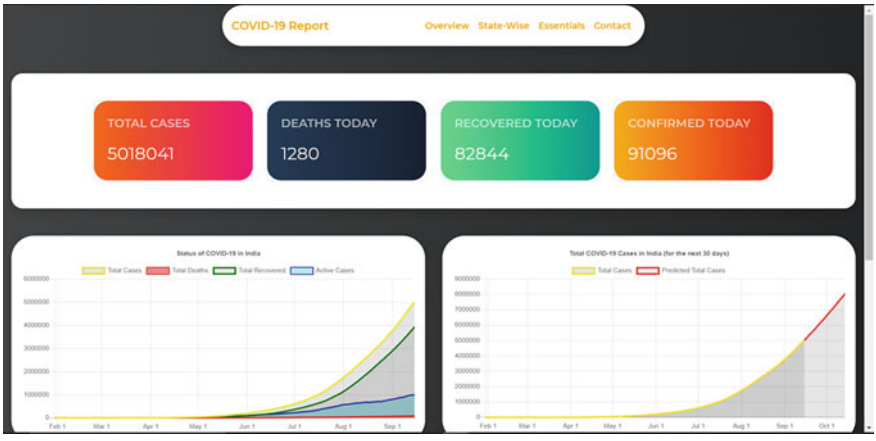


Fig. 1 Home page of the application (till September 15, 2020)

The uniqueness of the graphical representations deals with the ability for users to visualize the impact of COVID-19 for 30 days ahead of time. The prediction of future trends in COVID-19 is modeled with the help of deep learning. The model is trained to predict the future of the impact of COVID-19 in the future with a very close accurate approximation. The predicted values are very close to the real scenario, hence enabling the users to have an idea of how this horrific pandemic would spread, thus taking necessary precautions regarding the same [6]. Predictions are made for the total number of COVID-19 cases in India, active cases in India, daily reported cases in India.

The next tab of the web application holds information regarding the state-wise COVID-19 report. The tab elaborates on the total cases, total active cases, total deaths, total recovered cases, and the last updated time for every state in India. The information present in each cell also contains a daily increase/decrease count in the amount. This section contains the statistical information of the same for any particular state in India.

The next tab of the web application elaborates on the essentials and resources available during this pandemic. It is difficult to comprehend the effects that the pandemic has had in everyone's daily life. Government and health agencies are doing their best to help combat this crisis. Thus, this section of the web application contains details about the contacts, different resources provided by the government, and other agencies in a particular state that would the users in need. With the help of this information, the user is in complete leverage to contact the specific agencies in his/her area when required. Our goal of this chapter is to provide fruitful, genuine and reliable information for the user.

For quick and fast alerts regarding the same, a chatbot built on Telegram equips the user with an efficient way to view the details of COVID-19 in India. The chatbot responds to the queries laid down by the users by fetching relevant pieces of information regarding the query posted.

This system is to be further generalized to any type of pandemic that might hit us in the future. An application to provide the necessary information required to combat the pandemic would be fruitful now and in the coming future. By generalizing the system, it could be a household application that everyone could depend on when a pandemic as such strikes.

3 Proposed Modules

- **Info-card**: The information cards serve as quick snippets of COVID-19 information to the user. These cards contain information regarding the Total Number of COVID-19 Cases, Deaths on a particular day, Recovered Cases on the particular, and the Daily Confirmed Cases. The information cards provide a glimpse of the devastating impacts that the pandemic is having on India. In Fig. 2, the info card is shown details about the cases in each of the specified categories.

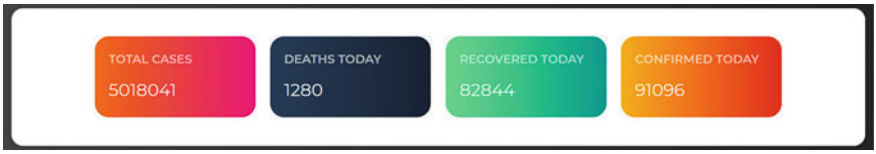


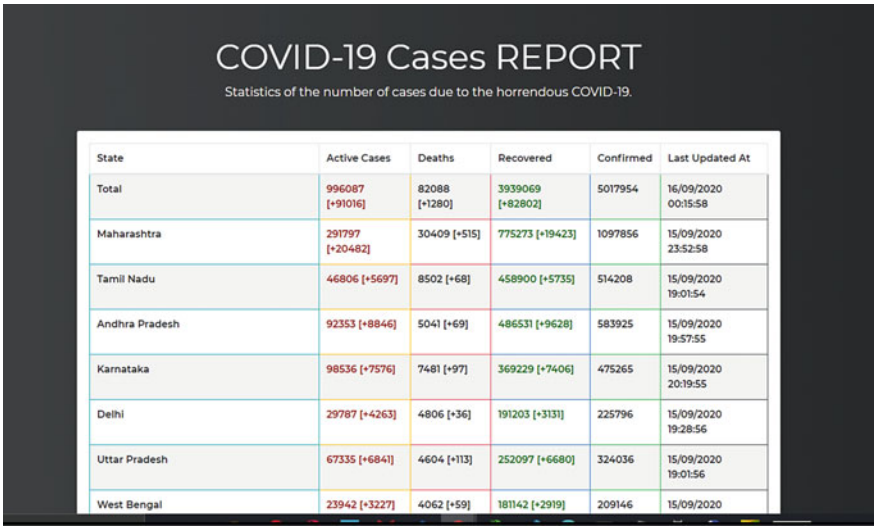
Fig. 2 Info-card (till 15th September 2020)

- **Visualizing section**: This section contains a graphical representation of the way COVID-19 has been progressing in India. are namely four graphs on the main page:
  - Real-Time status of COVID-19 in India: This graph contains the history of the entire COVID-19 cases reported in India till date, it includes Total Cases, Total Recovered Cases, Total Deaths, Active Cases.
  - Total COVID-19 Cases in India, along with prediction: This graph contains the total cases of COVID-19 reported in India to date, along with an intelligent prediction of how the cases would increase in the upcoming 30 days in advance.
  - Active COVID-19 Cases in India, along with prediction: This graph contains the active cases of COVID-19 reported in India to date, along with an intelligent prediction of how the cases would increase/decrease in the upcoming 30 days in advance. Active cases are a very crucial factor, emphasis is given on active cases as it is through this can one realize when it would peak and decrease accordingly.

    $$\text{Active Cases} = \text{Total Cases} - \text{Total Recovered Cases} -- \text{Total Deceased Cases}$$

  - Daily Confirmed COVID-19 Cases in India, along with prediction: This graph contains the daily confirmed cases of COVID-19 in India to date, along with an intelligent prediction of how the cases would increase/decrease in the upcoming 30 days in advance. Daily confirmed cases can be used to conclude how many people are affected depending on the number of people tested.
- **State-wise statistics**: This section details the statistics of COVID-19 impacts in all the states in India. The user is presented with a table which contains the following information:
  - State name.
  - Active Cases in the state.
  - Deaths in the state, due to COVID-19.
  - Recovered Cases in the state.
  - Total Confirmed Cases in the state.
  - Last Updated date and time.

In Fig. 3, illustrates the COVID-19 cases report detailing the case based statistics for each of the states in India. Each of the rows is described with detailed statistics



State	Active Cases	Deaths	Recovered	Confirmed	Last Updated At
Total	996087 [+91016]	82088 [+1280]	3939069 [+82802]	5017954	16/09/2020 00:15:58
Maharashtra	291797 [+20482]	30409 [+515]	775273 [+19423]	1097856	15/09/2020 23:52:58
Tamil Nadu	46806 [+5697]	8502 [+68]	458900 [+5735]	514208	15/09/2020 19:01:54
Andhra Pradesh	92353 [+8846]	5041 [+69]	486531 [+9628]	583925	15/09/2020 19:57:55
Karnataka	98536 [+7576]	7481 [+97]	369229 [+7406]	475265	15/09/2020 20:19:55
Delhi	29787 [+4263]	4806 [+36]	191203 [+3131]	225796	15/09/2020 19:28:56
Uttar Pradesh	67335 [+6841]	4604 [+113]	252097 [+6680]	324036	15/09/2020 19:01:56
West Bengal	23942 [+3227]	4062 [+59]	181142 [+2919]	209146	15/09/2020

Fig. 3 State-wise statistics COVID-19 in India (the number enclosed between "[ ]" denotes the daily increase/decrease) (till 15th September 2020)

regarding the different categories of cases including Active Cases, Deaths, Recovered Cases, Total Confirmed Cases.

- **Essentials and Resources**: This section details the contact of agencies who would provide a helping hand in cases of COVID-19 related issues and much more in a particular location. The user is presented with a search interface, where the state name is provided as a query and the details of all the government agencies and help groups would be presented. We all owe a big salute to the people who are out there in the most hazardous conditions to help people. Figure 4 describes the Essentials and Resources section, the user is prompted to enter the state name and then to hit 'Click to Select State'. After doing so, the request is sent to the server which fetches the details about the state name and is printed in a tabular format.
- **Telegram Chatbot**: The Telegram chatbot incorporates all the qualities of a reliable, easily accessible source of information. The chatbot will be able to provide real-time information on COVID-19 cases. The user can view national-wide, state-wise information immediately and the chatbot fetches the relevant details such as total cases, active cases, recovered cases, deaths.

Figures 5 and 6 detail the interface of the Telegram chatbot where the user enters the commands such as overview and state-specific details. The details are presented to the user as a text message and the details are presented in the same.

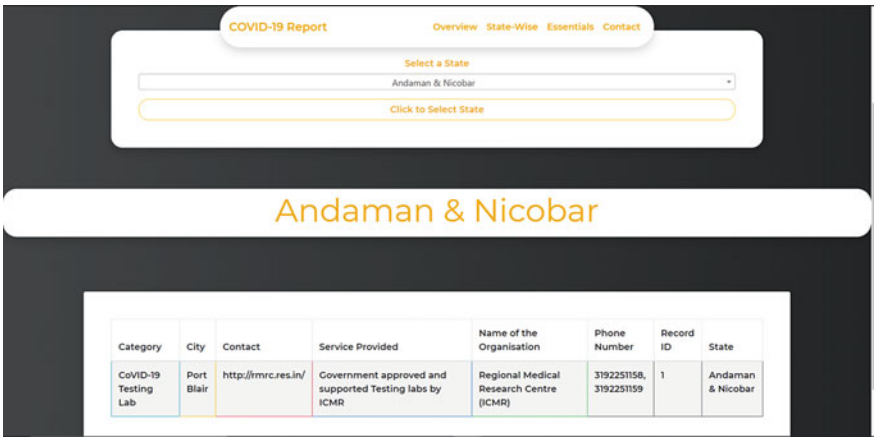


Fig. 4 Essentials and resources

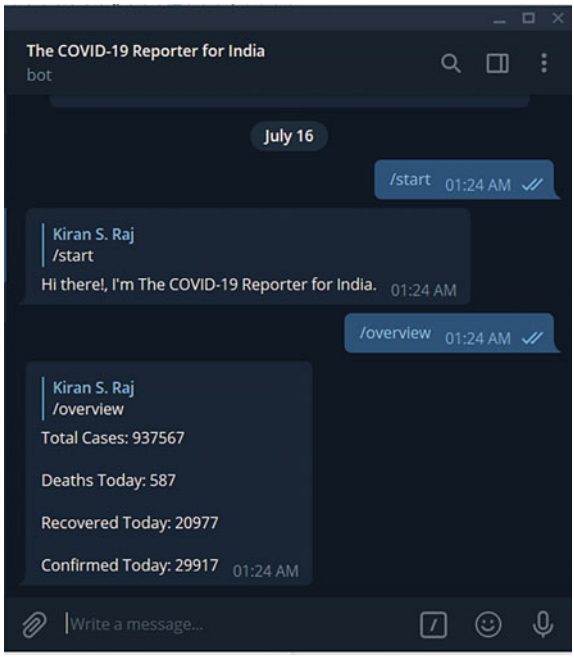


Fig. 5 Telegram chatbot—overview

4 Deep Learning

The twenty-first century has been revolving around the developments in technology orchestrating to a much more complicated and sophisticated artificially intelligent system. Most of the innovations that took place in the field had a direct/indirect

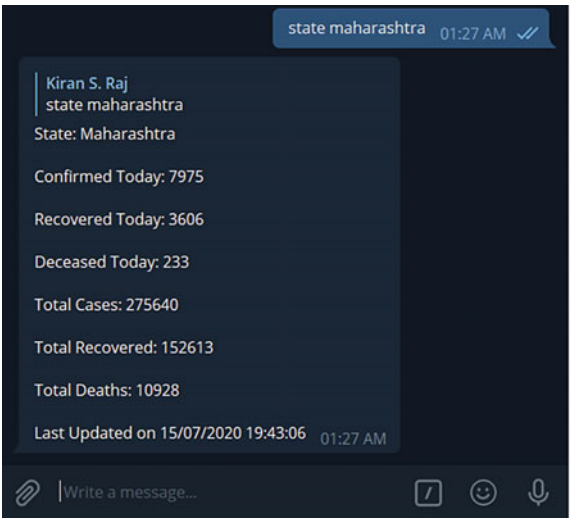


Fig. 6 Telegram chatbot—state-wise selection

relation to the concept of deep neural networks. The human brain being the source of motivation has helped the computer researchers to craft one of the most innovative architectures based on forward propagation for computing results and back propagation for correcting or improving the predictions, hence the birth of deep learning. The reasons why deep learning has proved to be an important factor when designing the model for the COVID-19 prediction has to revolve around the facts that deep learning models learn complex mathematical function/trends, once stabilized its ability to generalize over most of the input conditions, its ability to tolerate variations from data distributions provided as input to the model, and its ability to extract features from the training set which would then be an important factor to be considered in prediction. Compared to the statistical methods, deep learning architectures outperform them when it comes to its ability to learn all these complicated mathematical functions (multivariate inputs), feature extraction, and the essence of generalizing the predictions over a wide spectrum of inputs [7].

For the current problem statement, convolutional neural networks have been used as the architecture of choice [8]. It can generate feature maps and extract the most important features through convolutional layers, map to the outputs, and generate a prediction that would be a close approximation to the ground truth.

4.1 CNN Model

With the help of the convolutional neural networks on the input data, feature maps are created to extract the components that would play a big role in predicting the progress of COVID-19 with real-life approximations as accurately as possible. With the help of convolutional layers, features are grained out to form feature vectors which are

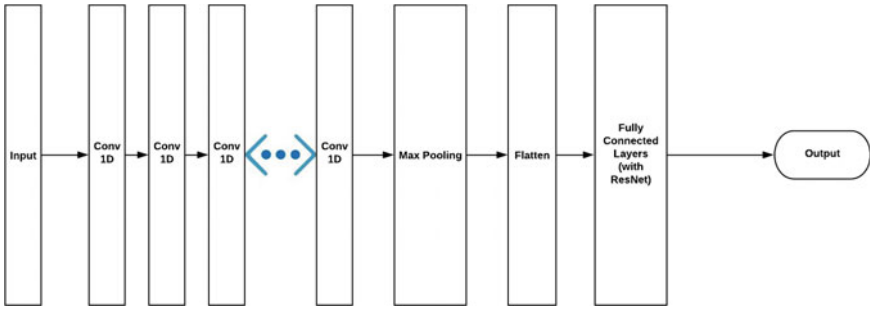


Fig. 7 CNN model used for prediction

then flattened out in a fully connected layered system with a ResNet architecture to provide that dependency on different layers. The results produced simulate the effect of how COVID-19 would progress in the upcoming periods. Figure 7 shows the architecture used in developing the prediction algorithm for COVID-19 cases.

$$x_i^l = \tanh\left(\max_{\text{pooling}}\left(\sum_j x_i^{l-1} * w_{ji}\right) + b_i^l\right)$$

where

x_i^l is the map of features obtained after passing through the lth convolutional layer.
w is the weight vector associated with the feature vectors.

This modeling of dealing with the prediction of COVID-19 cases in India with the help of convolutional neural networks helps in predicting values that closely represent the real-world scenario [9]. On further extending the scope to states, the answer to, "How well a particular state is doing?" can be approximated with the help of this approach. On analyzing when the peak would be hit or when the cases have to decrease, one can come to a conclusion regarding the status of COVID-19 in the particular state. This approach can provide insightful information on when people can go out in life returning to normalcy. The results obtained from the approach provide very close approximations to the real-life situation, hence providing a helping tool to have an understanding of how COVID-19 would progress in India.

5 System Implementation

China was the first one to report the case of COVID-19 and as time progressed they were able to flatten the cure. On studying the way COVID-19 progressed in China [10] and analyzing how the trends changed, it is safe to say that the active cases would hit a peak and then drop off. This happens when the active cases are less

than the recovered cases, in such a way that the first derivative would be negative and would decrease.

The difficulty in the prediction of such trends deals with the variations and randomness of how the COVID-19 cases would change daily. The factors that would cause such a change include the effects of lockdowns in regions, practices about the prevention of COVID-19 (mask, social distancing), and also the number of tests taken. All these attributes influence the number of cases of COVID-19 reported; hence, it is necessary to understand the underlying trends, variations in the data to predict a close approximation of it in the coming days.

Hence, there requires a system to understand the trend of the temporal quantity to predict in such a way to maintain the correlations between the data and the effective sequence of how the trend follows.

Deep neural networks can estimate nonlinear functions at a very accurate approximation, handle noise present in the data, and good generalization for the time series prediction for a longer period. This is done by taking into account the correlations present within the data and trends, periodical, seasonal nature followed by the COVID-19 data over some time.

Figure 8 displays the process of prediction of the COVID-19 cases in India takes place in the following steps. The first step involves fetching the data details regarding COVID-19 cases from the API. The fetched data is then preprocessed and visualized. The visualization gives a brief idea of how the data points are changing with respect to time. After the preprocessing step and seasonal decomposition, the data is fit to the convolutional neural network model and training. The training would generate the necessary features map and stabilize the weights in the fully connected layers. Then the future trends are then predicted, the convolutional neural networks take into consideration the patterns associated with the changing trends of COVID-19 cases, and also the cases tested. The output from the model is then plotted onto a graph and projected on the web applications for the users to see (Fig. 9).

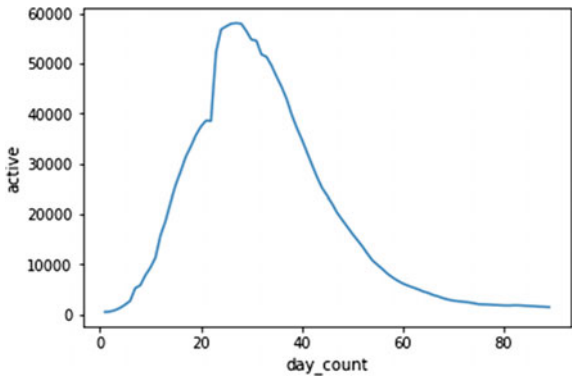


Fig. 8 Active cases in China over the period

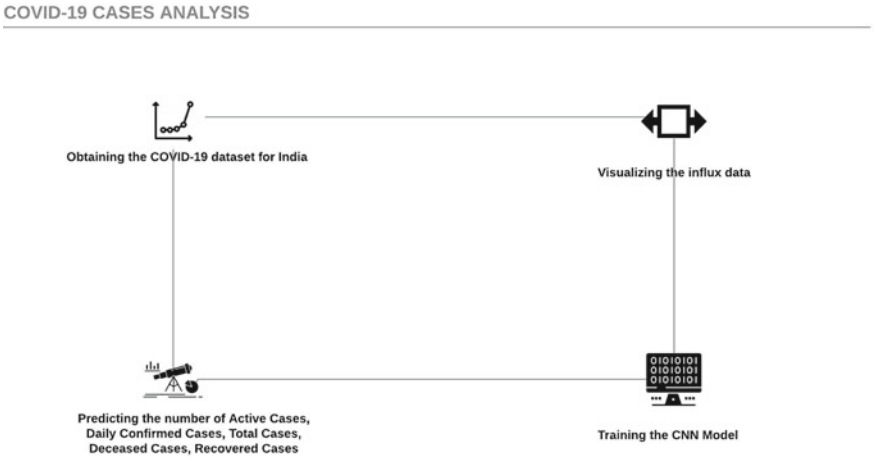


Fig. 9 Process of predicting the COVID-19 cases in India

5.1 Decomposition of the COVID-19 Data

$$\text{COVID-19 Time Series}(t) \rightarrow \text{Seasonal}(t) \times \text{Trends}(t) \times \text{Cyclical}(t) \times \text{Irregularity}(t)$$

- **Trends**—represents the persistent increase or decrease of the values along with the overall flow of the data.
- **Seasonal**—occurs when there exists a seasonal in the change of the data over a particular time.
- **Residual**—this denotes the noise/irregularity present in the data that influences the flow over a period of time.

In Fig. 10, the first graph represents the actual COVID-19 progression graph over the days, the second graph represents trend analysis decomposed from the main graph, the third graph represents the seasonal analysis decomposed from the main graph, and the last graph represents residual analysis from the main graph.

6 Results and Analysis

The performance of the trained proposed model is very accurate to real-world data, owing to the architecture underneath and feature map used for training the model. The model also can correct itself from random outliers present along the period; this flexibility enables the model to predict values which would give a rough idea of how the COVID-19 cases would progress in the upcoming days. The following are the error rates providing a rough validation of the accuracy of the model.

From Figs. 11 and 12, the relative absolute error in prediction and the actual cases are represented. From the visualization, we can infer that the error is initially high

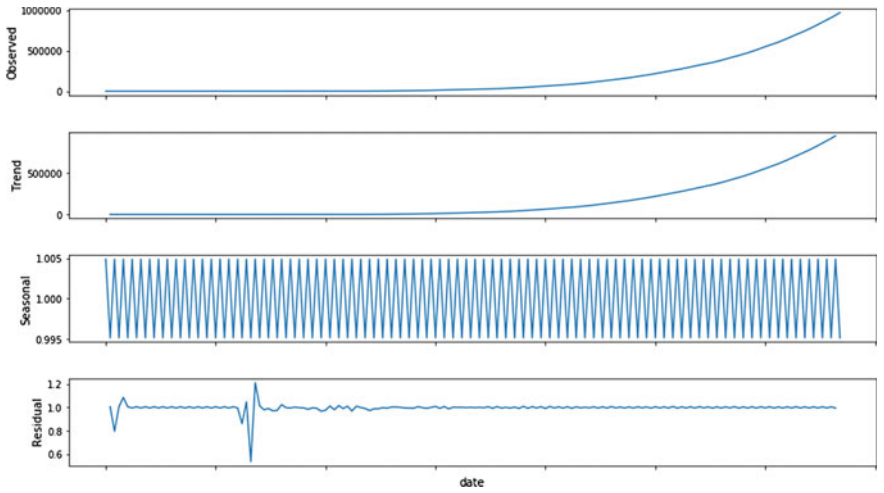


Fig. 10 Decomposition of the COVID-19 data

Fig. 11 Relative absolute error in the total number of COVID-19 cases

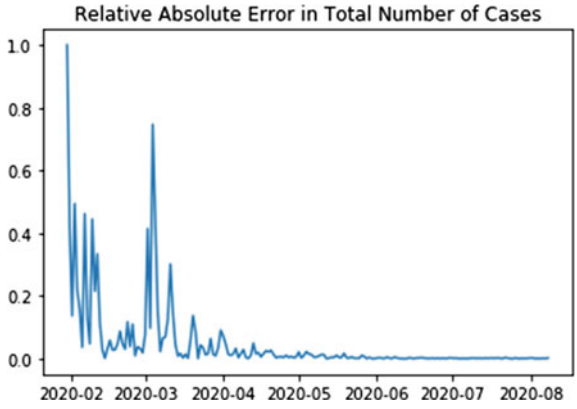
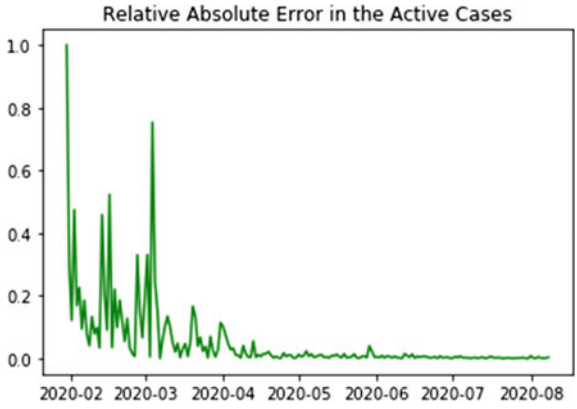


Fig. 12 Relative absolute error in the total number of active cases



but over time, it drops to the bare minimum, and hence, the accuracy of the model is validated by showing the close approximation of prediction to the real-world data.

The following are the results generated by the model and visualized.

Figure 13 illustrates the current status of COVID-19 in India highlighting the active cases, recovered cases, total cases, and deaths. In Fig. 14, the user can visualize the total cases of COVID-19 in India along with the prediction of the cases for the next 30 days. With the help of Fig. 15, users can visualize the active cases of COVID-19 in India along with the prediction for the next 30 days. Figure 16 illustrated the daily confirmed cases of COVID-19 in India along with the prediction of how it is going to vary in the coming 30 days.

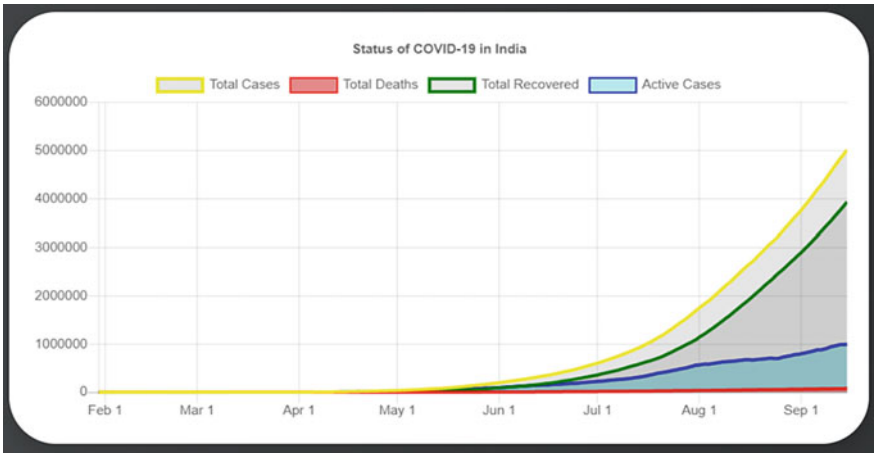


Fig. 13 Status of COVID-19 in India (till September 15, 2020)

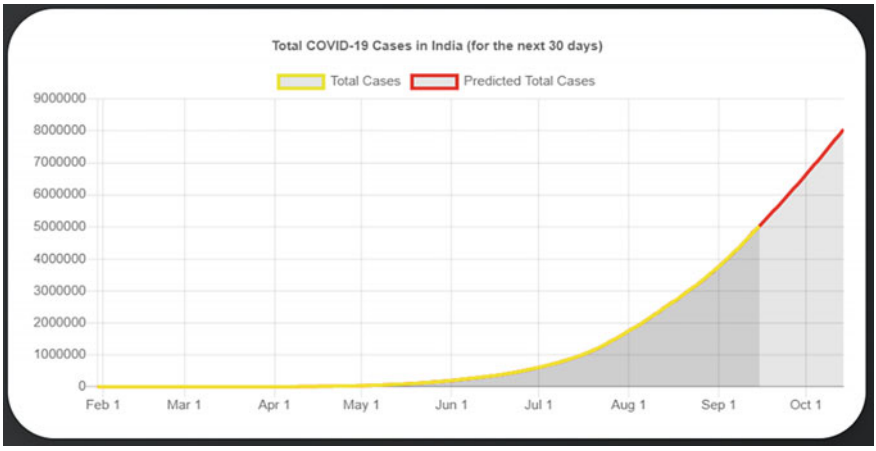


Fig. 14 Total of COVID-19 cases in India along with the prediction (till September 15, 2020)

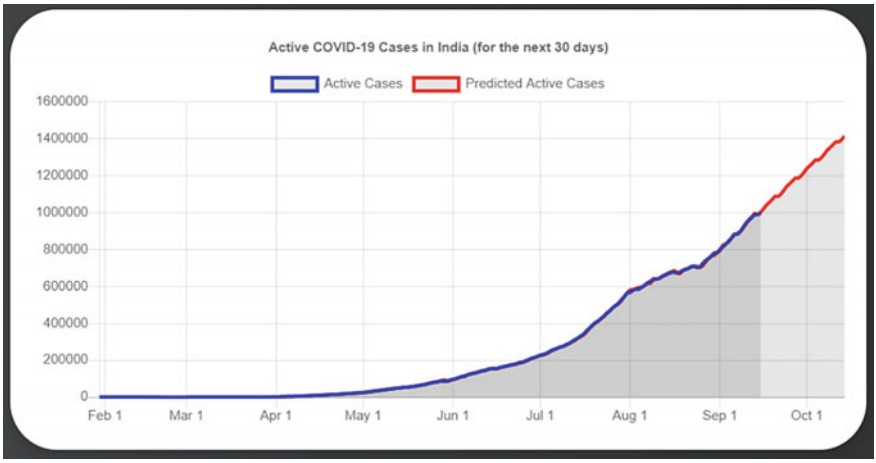


Fig. 15 Active number of COVID-19 cases in India with the prediction (till September 15, 2020)

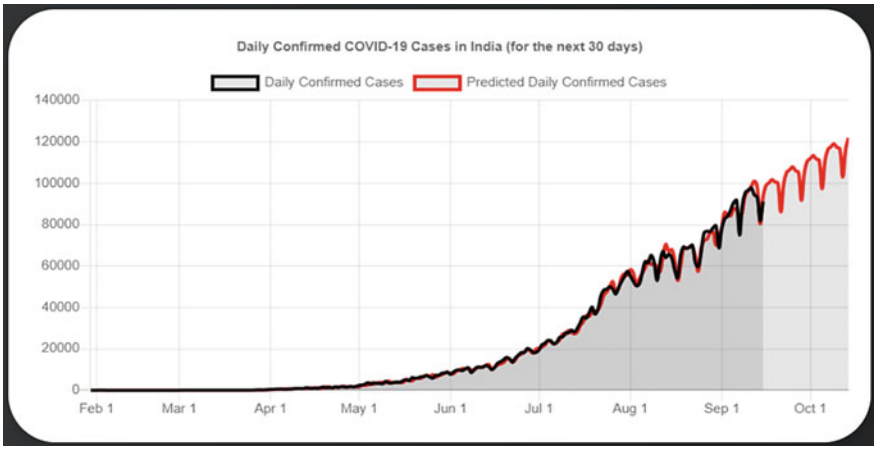


Fig. 16 Daily confirmed COVID-19 cases in India with the prediction (till September 15, 2020

7 Conclusion and Future Direction

In this chapter, we have created a web application that provides a comprehensive and elaborative visualization of the impacts COVID-19 has on India with the help of deep learning. This information is also appended with state-wise statistics, information regarding the essential resources, and Telegram chatbot, which would prove fruitful, enhance the experience from the users' perspective [11]. The prediction of the progress would enable a user to have a rough approximation of how the pandemic would spread across the future days and hence can be prepared in advance for the point

of impact. Our goal in this chapter is to provide meaningful information/inference that would help the people understand the extent of severity due to this pandemic and make them aware of how worse it could get with time. In India, where the faces of people are painted with joy and content, we feel that this is our obligation to put forth cutting edge technologies that would help them understand the situation better and bring that smile back onto their faces.

The future scope of this project would be to make the chatbot available in regional languages, generate a score-wise report on how well a particular state is doing to combat COVID-19 in that region and providing a report on the percentage of people affected, detailing out the number of ventilators available in that region and to provide a detailed view on how safe it would be to step out.

For more details, please view the web app (preferably in a laptop): https://covid-report-india.herokuapp.com/.

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