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Outbreak prediction of covid-19 in most susceptible countries

D. Yadav[1], H. Maheshwari[2], U. Chandra[3]

[1]*Department of Computer Science and Technology, Glocal University, Saharanpur, Uttar Pradesh, India*
[2]*Department of Computer Science and Engineering, Uttarakhand Technical University, Dehradun, Uttarakhand, India*
[3]*Department of Computer Science, Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India*

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ABSTRACT

Origin of the coronavirus was the seafood market of Wuhan city, Hubei province in China. The cases of someone suffering from COVID-19 can be traced back to the end of December 2019 in China. This is the most infectious disease and spread worldwide within three months after the first case reported. The World Health Organization renames Coronavirus as COVID-19. COVID-19 is the β-Coronavirus family virus, effect on the lung of human and common symptoms are cough, fever, fatigue, respiratory problem, and cold. The full name of the coronavirus is severe acute respiratory syndrome SARS-CoV. It spread on humans as well as animals and infected more than 183 countries with 2959927 confirm cases and 202733 deaths till 28 April 2020. 84 days data is used to predict confirmed and death cases for the next 10 days by using prophet and daily average based algorithm. Predicted confirmed cases are 2886183 and death cases 190540 till 25 April 2020. This study introduces the spreading pattern of COVID-19 in the top ten infected countries. After China, European countries are the most infected ones. In this study, data was analyzed on the attributes confirmed, active, recovered and death cases, and next ten days outbreak prediction. Some countries state-wise data confirmed active and death cases also analyzed.

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*Corresponding Author:
Email: *ydharminder@yahoo.com*
Phone: +7206 959856
Fax: +7206 959856

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INTRODUCTION

Coronavirus is not a new virus but the severe acute respiratory syndrome coronavirus, SARS nCoV is the new virus of the family Coronaviridae cases found in China (Dhama *et al.,* 2020; Geller *et al.,* 2012; Hui *et al.,* 2020; Zhu *et al.,* 2020; Li *et al.*, 2020). World Health organization officially renames SARS-CoV (SARS-nCoV) or Novel coronavirus as COVID-19 on 11 February 2020 (WHO, 2020; COVID-19, 2020). Alpha coronavirus, Beta coronavirus, Gamma coronavirus, and Delta coronavirus are the four genera of the family Coronaviridae (Stanley Perlman 2020; Woo *et al.,* 2010; Lim *et al.,* 2016; Weiss *et al.,* 2011). Bats are the source of COVID-19 virus and spread in humans as well as mammal (Richman *et al.,* 2016; Cohen *et al.*, 2020; Corman *et al.,* 2020; Cavanagh, 2007). The six human coronaviruses that can infect people are 229E, OC43, HKU-1, NL-63, severe acute respiratory syndrome coronavirus (SARS-CoV), and Middle East respiratory syndrome coronavirus (MERS-CoV) (Fouchier *et al.,* 2004; Vander Hoek *et al.,* 2004; WHO, 2003; WHO 2020). Zhu *et al.* (2019), but the novel coronavirus is new virus. SARS-CoV and MERS-CoV are the infectious virus of the Beta-coronavirus family which can affect the respiratory system of humans (Kuiken, *et al.,* 2003; Zaki *et al.,* 2012), till now there is no vaccine and medicine developed for the treatment of COVID-19 only precaution are the safety measures.(Mizumoto and Chowell, 2020; Riou and Althaus, 2020; Shao and Wu, 2020). Incubation of coronavirus is 2 to 14 days (Tanu 2020; Zunyou *et al.,* 2020). W. Xia *et al.,* (2020), discuss the indication that the transmission of COVID-9 occurs during the incubation period. Ranjan (2020) used SIR model to predict the outbreak of COVID-19 in India on the daily bases and found consistence result with confirmed and death cases. Social distancing and lockdown is the weapon to fight with COVID-19. Tomar and Gupta (2020) predicted the confirmed cases in India for next 30 days by using long short-term memory (LSTM) algorithm and effect of precaution measures in spread of coronavirus. The research has been conducted on a sample of data collected from the kaggle and experiments with studies the cases of coronavirus worldwide, top infected countries of the world date-wise by using the python language in Jupyter notebook. “COVID-19” affects the 183 countries with 2056051 confirmed cases, 502045 recovered cases, and 1419829 active cases till 15 April 2020. This study indicates the spreading pattern of COVID-19 of top countries such as the United States of America, Italy, China, Spain, Germany, and Iran date-wise. It is analyzed that the countries’ wise and state wise data for the better understanding outbreak of COVID-19. It is shown the countries wise confirmed cases on the thematic Map. Predict the future confirmed case in the USA, China, and Rest of the World, find the accuracy of prediction. These countries medical facilities are highly rated and the most developed in the world (Tandon *et al.,* 2000; Pouillier *et al.,* 2000; WHO, 1999). In this study, the data was analyzed from 22 January 2020 to 15 April 2020.

MATERIALS AND METHODS

Fig. 1 depicts the general methodology of the given study. To perform the spreading pattern of COVID-19, data was collected from kaggle site and other sources, which contains 183 country data with 22270 rows and 8 columns. These eight columns are renamed as states, country, longitude, latitude, date, confirmed, recover, and deaths. Few countries give their data sate-wise i.e. China, Italy, Australia, France, US, United Kingdom, and others, but 9882 rows of state columns are NaN (Not a number or no value in cell), replace these NaN, with empty white space. This data undergoes various steps of pre-processing which makes it more sensible. Then, for data analysis calculate the active case worldwide by subtracting recover and death cases from the confirmed cases. 84 days of data are collected from 22 January 2020 to

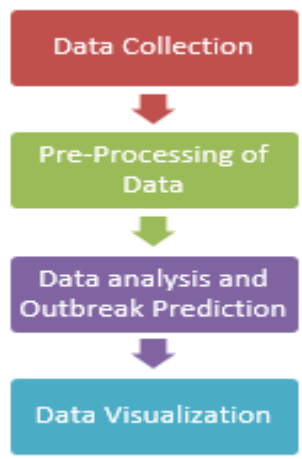

Fig. 1: General methodology for the study

15 April 2020, ranking change with every upcoming day due to coronavirus infection. In this study, overall data is divided into 11 parts i.e. top ten infected countries till 15 April 2020 namely China, Italy, United States, Iran, Canada, United Kingdom, Australia, France, Spain and the last one is 'rest of the world' which internally contains 183 country data.

RESULTS AND DISCUSSION

For the data analysis, python language with package NumPy, Pandas, and Plotly were used. Fig. 2 shows the worldwide confirmed recovered, death and active cases which depicts on 6 March 2020, confirmed cases of COVID-19 crosses the 100 thousand in 45 days while from 12 March 2020, a sudden spike comes and confirmed cases of coronavirus reached to 3,55,955 within 16 days i.e. confirmed cases becomes 3.5 times and increasing rapidly. The recovered cases of coronavirus patients are slow but after 16 February, there is some improvement in recovered cases and total recovered cases on 15 April 2020 are 2056051. The death cases are very slow in coronavirus infected patient till 16 March 2020, however but after 16 March death cases are increases and total death cases on 15 April 2020 are 134177. China is the most infected country from coronavirus with total confirmed case 81397, recovered case 72362, and 3265 deaths as of 22 March 2020 after that starting from 15 April 2020; United States of America has become the country with highest number of confirmed cases, followed by Spain, Italy, and Germany. Infection of coronavirus started from china but there is a sudden spike in confirmed cases at the end of January, after 23 February 2020 china control the coronavirus infection and confirmed case are stable. There is an improvement in recovered cases after 9 February 2020 and a sudden decline in active cases after 18 February (Fig. 3). Figs. 4, 5, and 6 shows the confirmed, recovered active, and death cases of the Italy, USA, and Iran. Figs. 7, 8, 9,

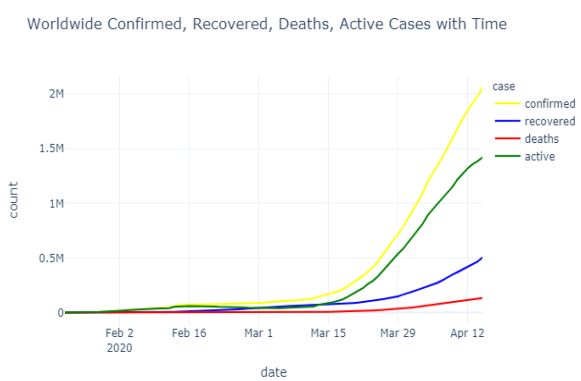

Fig. 2: **Worldwide** confirmed, recovered, deaths, active cases

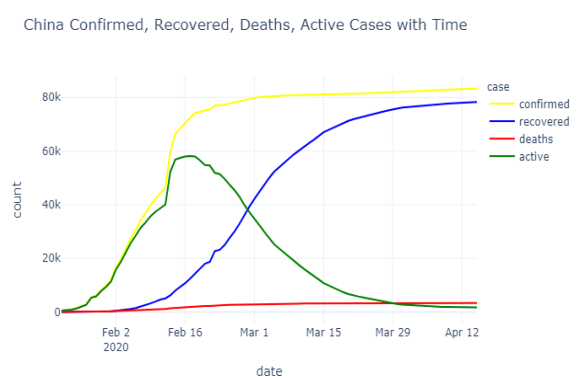

Fig. 3: Confirmed recovered, deaths, active in **China**

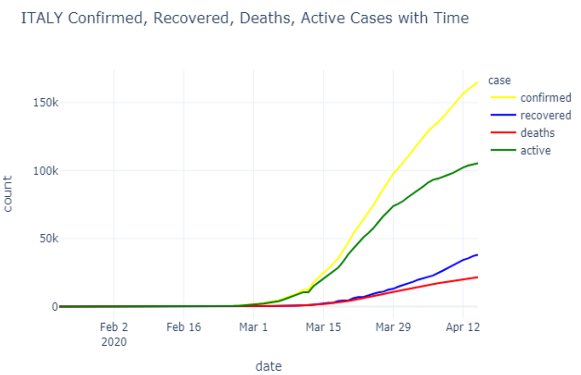

Fig. 4: Confirmed, recovered, deaths, active cases in **Italy**

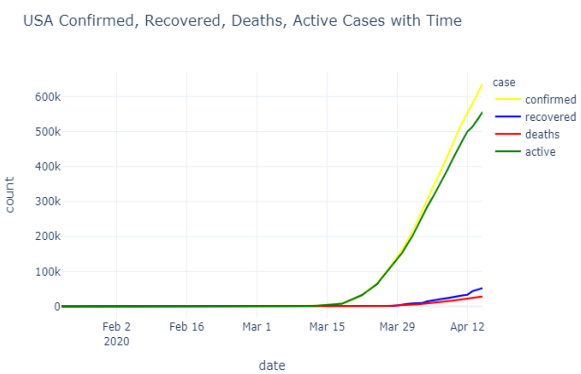

Fig. 5: Confirmed recovered, deaths, active in the **USA**

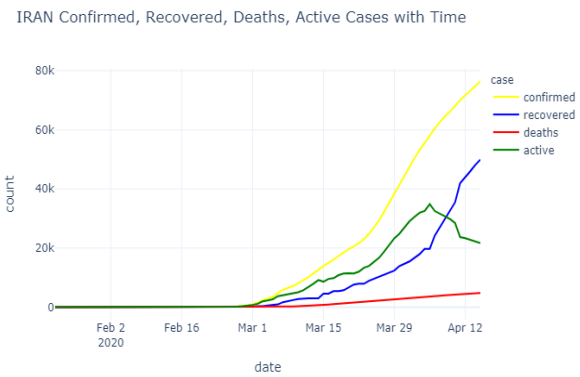

Fig. 6: Confirmed recovered, deaths, active in **Iran**

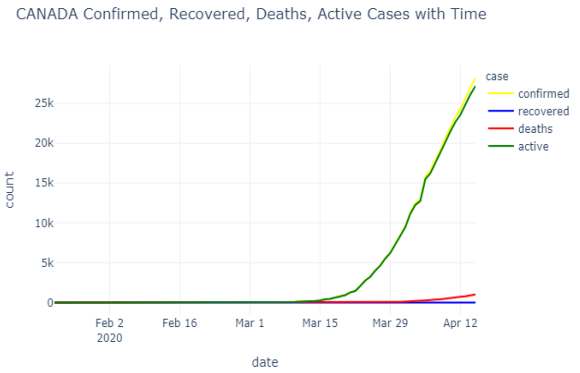

Fig. 7: Confirmed, recovered, deaths, active cases in **Canada**

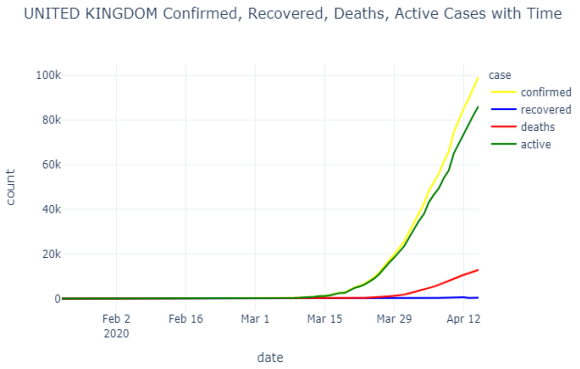

Fig. 8: Confirmed recovered, deaths, active in **UK**

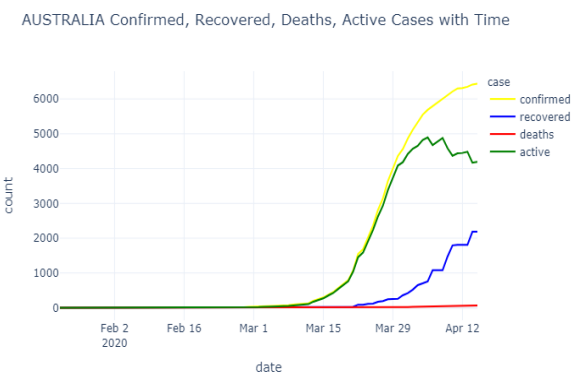

Fig. 9: Confirmed, recovered, deaths, active cases in **Australia**

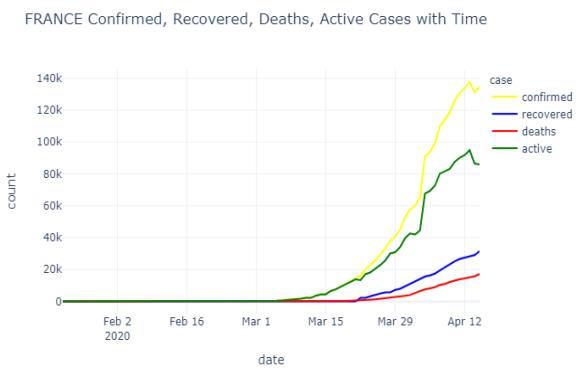

Fig. 10: Confirmed recovered, deaths, active in **France**

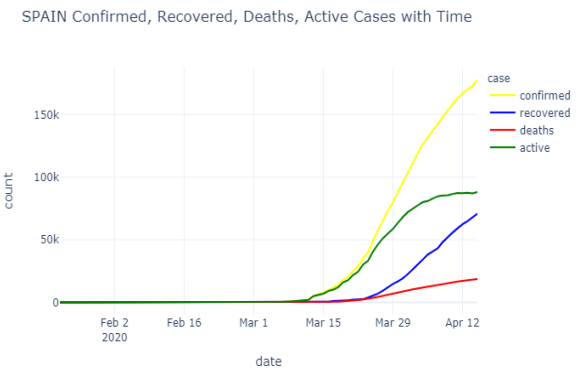

Fig. 11: Confirmed, recovered, deaths, active cases in **Spain**

10 and 11 shows the confirmed, recovered active, and death cases of the Canada, the United Kingdom, Australia, France, and Spain respectively. In Italy, the USA, Iran, Canada, United Kingdom, Australia, France, and Spain infection started in the first week of March; it has reached at pandemic level within two weeks. These countries confirmed cases are 165155, 636350, 12322, 76389, 28208, 99483, 6440, 134582, 177644 and death cases are 21645, 28326,405, 4777, 1006, 12894, 62, 17188, and 18708 respectively.

The recovery rate in these countries is very slow or negligible so that the line graph of confirmed cases and active cases overlapping each other. Iran shows improvement in coronavirus patients and 21679 patients recovered but after 15 March 2020 suddenly decline in active cases. The cases of coronavirus are continuously increasing in the world and conditions of these countries going to worsen due to infection. Even after better medical facilities are available in those countries still the recovery of coronavirus patients is very slow and the number of confirm cases increase every day.

Fig. 12 shows the confirmed (636122), recovered (177304), deaths (25819), and active (432999) cases in the Rest of the World. The rest of the world includes all the 173 countries excluding the above 10 countries. In the graph confirmed and active case lines are overlapping each other due to no improvement in the condition of patients. Fig. 13 shows the thematic map of the world with confirmed cases in the whole world. Choropleth maps function is used to show a better statistic over a geographical area. The darkness on the map depicts that these countries are with more than 5000, lighter color depicts, with fewer cases. Interactive thematic map shows the country name, confirmed case, and deaths cases. In this study, the state-wise effect of coronavirus is given in Table 1 for 7 countries (i.e. Australia, China, United States of America, Canada, Italy, France and the United Kingdom). It is shown that the 10 countries state-wise confirmed recovered and death cases but only seven countries state-wise data found. The recovered and confirmed cases are highest in china, but active and death cases are highest in Italy worldwide.

The recovery rate of china is 93.95% on the top and the recovery rate of Canada is nearly zero percent at the bottom. Iran, Italy, France, and Spain recovery rates are 65.37, 23.06, 23.38, 39.88 percent and ranks

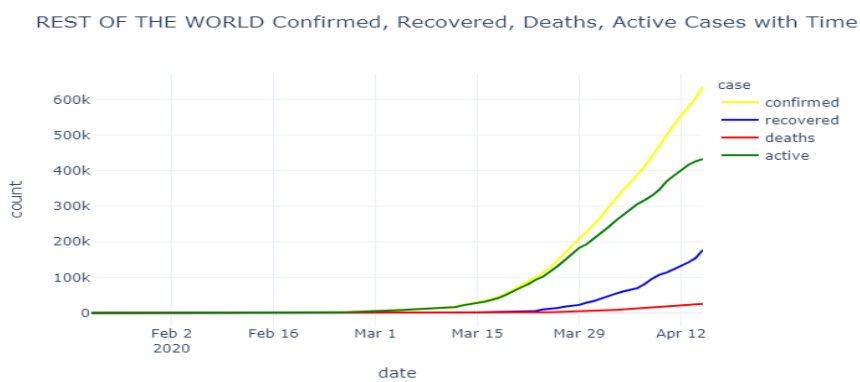

Fig. 12: Confirmed, recovered, deaths, active in **Rest of World**

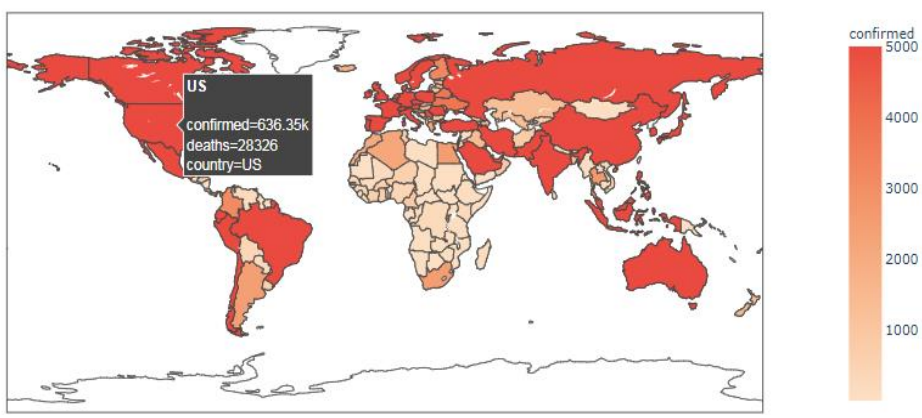

Fig. 13: Countries wise confirmed on World map

Table 1: State-wise data of Eight countries

S.N.	Country	State	Confirmed	Recover	Death	Active
1	Australia	New South Wales	2886	4	25	2857
		Victoria	1299	1118	14	167
		Queensland	999	442	5	552
		South Australia	433	240	4	189
		Western Australia	527	251	6	270
		Tasmania	165	53	6	106
		Australian Capital Territory	103	72	3	28
		Northern Territory	28	6	0	22
2	China	Zhejiang	1268	1244	1	23
		Hunan	1019	1014	4	1
		Anhui	991	984	6	1
		Jiangxi	937	936	1	0
		Shandong	784	761	7	16
		Jiangsu	653	642	0	11
		Chongqing	579	570	6	3
		Sichuan	560	550	3	7
		Heilongjiang	841	470	13	358
		Beijing	590	495	8	87
3	France	France	133470	30955	17167	85348
		French Guiana	86	51	0	35
		French Polynesia	55	0	0	55
		Guadeloupe	145	67	8	70
		Martinique	158	73	8	77
		Mayotte	217	69	3	145
		New Caledonia	18	1	0	17
		Reunion	391	237	0	154
		Saint Barthelemy	6	4	0	2
		Saint Pierre and Miquelon	1	0	0	1
		St Martin	35	13	2	20
4	Canada	Ontario	8447	0	385	8062
		British Columbia	1517	0	72	1445
		Alberta	1870	0	48	1822
		Quebec	14860	0	487	14373
		Saskatchewan	304	0	4	300
		Manitoba	246	0	5	241
		Nova Scotia	549	0	3	546
		New Brunswick	117	0	0	117
		Grand Princess	13	0	0	13
		Newfoundland and Labrador	247	0	3	244
5	United Kingdom	United Kingdom	98476	12868	0	85608
		Channel Islands	447	15	69	363
		Gibraltar	131	0	104	27
		Cayman Islands	54	1	6	47
		Bermuda	81	5	33	43
		Isle of Man	256	4	151	101
		Montserrat	11	0	1	10
		Anguilla	3	0	1	2
		Turks and Caicos Islands	10	1	0	9
6	United States of America	New York	214454	0	11617	202837
		New Jersey	71030	0	3156	67874
		Massachusetts	29918	0	1108	28810
		Michigan	28059	0	1921	26138
		Pennsylvania	26753	0	779	25974
		California	26686	0	860	25826
		Illinois	24593	0	949	23644
		Florida	22511	0	596	21915
		Louisiana	21951	0	1103	20848
		Texas	15907	0	375	15532
7	Italy	Lombardia	62153	17855	11377	32921
		Emilia-Romagna	21029	4664	2788	13577
		Piemonte	18229	3019	2015	13195
		Veneto	14624	2895	940	10789
		Toscana	7666	693	556	6417
		Liguria	5936	1665	807	3464
		Marche	5503	1660	746	3097
		Lazio	5232	874	311	4047
		Campania	3807	442	278	3087
		P.A. Trento	3220	798	318	2104

Table 2: Recovery and mortality rate per 1000 confirmed cases

S. No.	Country	Confirmed	Deaths	Recovered	Recovery rate (%)	Mortality rate (%)
1	Italy	165155	21645	38092	23.06	13.11
2	United Kingdom	99483	12894	368	0.36	12.96
3	France	134582	17188	31470	23.38	12.77
4	Spain	177644	18708	70853	39.88	10.53
5	Iran	76389	4777	49933	65.37	6.25
6	US	636350	28326	52096	8.18	4.45
7	China	83356	3346	78311	93.95	4.01
8	Canada	28208	1006	0	0	3.57
9	Germany	134753	3804	72600	53.88	2.82
10	Australia	6440	63	2186	33.94	0.98

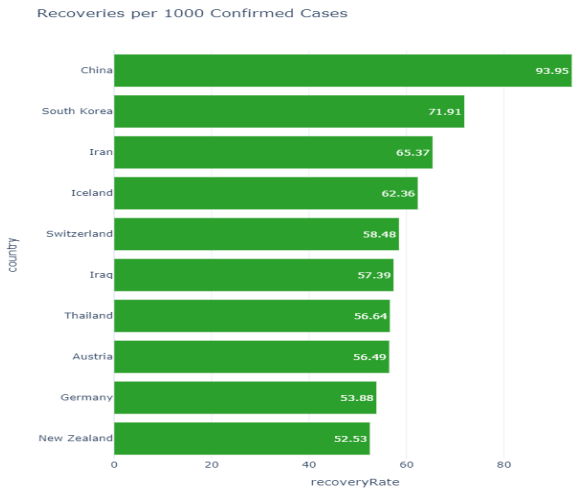

Fig. 14: Top 10 countries recovery rate per 1000 confirmed cases

second, third, fourth, and fifth place respectively (Fig. 14). The mortality rate of Italy is on top with 13.11 % and Australia at the bottom (Table 2). The formula used to calculate mortality and recovery rate is given using Eq. 1.

$$\text{recovery rate} = \frac{\text{Death case}}{\text{Confirmed cases}} * 100$$
$$\text{Mortality rate} = \frac{\text{Death case}}{\text{Confirmed cases}} * 100 \quad (1)$$

Table 2 gives the Recovery and Mortality rate per 1000 confirmed cases of the top 10 countries. Worldwide mortality rate of Algeria is on top with 15.56 % and Bhutan at the bottom with 0 percent.

Outbreak prediction for the US, China and the rest of the World

Machine learning is the subpart of artificial intelligence. It is not a computer programming but a set of rules by using statics function predicts the better output for given data in limited time. The prophet is the time series forecasting algorithm for future prediction and Implemented in Python and R. Python and R are the programing language that is used for machine learning and data analysis. It is open-source software developed by Facebook. It is an adaptive model which uses nonlinear data to predict for yearly, monthly, and daily excluding holiday (Taylor *et al.,* 2017). Prophet easily handles missing data and outliers of the trend. The prophet is accurate and fast because it used a state-of-the-art platform for statistical modeling that provides forecast in very quickly. In this study, this algorithm was used for prediction of confirmed case for the United States of America, China and Rest of World for next 10 days shown in Table 3. "yhat" ("yhat" means Average Predicted confirmed and death cases) represent the predicted value, "lower" and "upper" represent the minimum and maximum value of prediction, and "y" represents the actual value. Table 4 shows the prediction of death cases for the United States of America, China, and the Rest of the World for the next 10 days by using Prophet Algorithm. Table 5 shows the prediction confirmed and death cases for the United States of America, China, and the Rest of the World for the next 10 days by using daily average growth. Daily average growth algorithm predicts the confirmed cases when government does not take safety measure such as social distancing and lockdown. If countries do not take

Table 3: Prediction of confirmed cases for US, China and the World using prophet algorithm

Date	Predicted for USA	Actual for USA	Change in % for USA	Predicted for China	Actual for China	Change in % for China	Predicted for World	Actual for World	Change in % for World
16-04-2020	669312	604070	+9.75	84104	83797	+0.36	2154428	1995955	+7.36
17-04-2020	700158	632781	+9.62	84254	84149	+0.12	2238392	2078577	+7.14
18-04-2020	730910	665330	+8.97	84100	84180	-0.10	2321808	2164078	+6.79
19-04-2020	760812	695353	+8.60	84117	84223	-0.13	2400819	2246258	+6.44
20-04-2020	789669	723605	+8.37	83874	84239	-0.43	2477919	2318655	+6.43
21-04-2020	818965	751273	+8.27	83843	84253	-0.49	2555615	2402251	+6.00
22-04-2020	848389	776907	+8.43	84211	84288	-0.09	2635644	2475699	+6.07
23-04-2020	879123	800926	+8.89	84731	84303	+0.51	2718803	2549610	+6.22
24-04-2020	909969	830053	+8.78	84881	84312	+0.67	2802768	2631699	+6.10
25-04-2020	940721	860772	+8.50	84727	84324	+0.48	2886183	2724808	+5.59

Table 4: Prediction of death cases for US, China, World using prophet algorithm

Date	Predicted for USA	Actual for USA	Change in % for USA	Predicted for China	Actual for China	Change in % for China	Predicted for World	Actual for World	Change in % for World
16-04-2020	27207	25871	4.91	3361	3352	0.27	136930	131034	+4.31
17-04-2020	28724	28221	1.75	3357	4642	-27.68	143056	139507	+2.48
18-04-2020	30242	30384	-0.47	3369	4642	-27.42	149091	146188	+1.95
19-04-2020	31727	32427	-2.21	3366	4642	-27.49	154924	152694	+1.44
20-04-2020	33098	34203	-3.34	3374	4642	-27.32	160514	157955	+1.59
21-04-2020	34628	35884	-3.63	3377	4642	-27.25	166469	163073	+2.04
22-04-2020	36179	37602	-3.93	3369	4642	-27.42	172570	169132	+1.99
23-04-2020	37463	40073	-6.97	3382	4642	-27.14	178380	175807	+1.44
24-04-2020	38981	42311	-8.54	3377	4642	-27.25	184505	182097	+1.31
25-04-2020	40498	44053	-8.78	3390	4642	-26.97	190540	187844	+1.42

Table 5: Prediction of confirmed and death cases for US, China, World using average daily growth

Date	Prediction of confirmed cases on the basses of average daily growth			Change in % with actual confirmed case world	Prediction of death cases on the basses of average daily growth			Change in % with actual death case world
	USA	China	World		USA	China	World	
16-04-2020	527604	77585	1830928	-9.01	41404	3591	121033	-8.26
17-04-2020	627849	82240	2014021	-3.21	52169	3824	134346	-3.84
18-04-2020	747140	87175	2215423	2.32	65733	4073	149124	1.97
19-04-2020	889096	92405	2436965	7.83	82824	4337	165528	7.75
20-04-2020	1058025	97950	2680661	13.50	104358	4619	183736	14.03
21-04-2020	1259049	103827	2948728	18.53	131492	4919	203947	20.04
22-04-2020	1498269	110056	3243600	23.67	165679	5239	226381	25.29
23-04-2020	1782940	116660	3567960	28.54	208756	5580	251283	30.04
24-04-2020	2121699	123659	3924756	32.95	263033	5942	278924	34.71
25-04-2020	2524821	131079	4317232	36.89	331421	6329	309606	39.33

precaution measure then confirmed and deaths cases are much more than predicted confirmed cases by daily average algorithm. Prophet algorithm provides better predicted result because it includes the fluctuation with time series data. Calculate the daily average growth of confirmed and deaths cases and predict the future confirmed and death cases. Graphs related to outbreak prediction are given in the appendix.

CONCLUSION

The proposed study focuses on analyzing the effect of COVID-19 on the top ten infected countries of the world. These countries not only included the most economically developed countries like the USA but also covered the most populated countries of the world like China. In the current study, authors tried to map the current conditions in terms of COVID-19 spreading after so many steps taken by the different governmental agencies of the top ten infected countries with the predicted value for the next ten days. This analysis can help government agencies for better decision-making. The researcher also analyzes the state-wise infection in five countries China, Australia, the United States of America, the United Kingdom, and Italy. China is having the highest confirmed case and recovered case. The infection of COVID-19 starts spreading worldwide at the end of February but in china, in the mid of February confirmed cases of COVID-19 become stable and sudden spike comes in recovered cases. After China, Italy, the US, Spain, and Iran are the most infected ones. Algeria has the highest mortality rate of 15.56% and Canada at the bottom with 0% in the world but in top ten countries mortality rate of Italy in on top and Australia at bottom. China has the highest recovery rate of 93.95% and Bhutan has the least nearly 0 % till 15 April 2020. In this study, a machine learning data-driven Prophet Time series forecast algorithm has been used to predict the outbreak analysis of COVID-19 in the United States of America, China, and the rest of the world for the next ten days i.e. 16/04/2020 to 25/04/2020.

AUTHOR CONTRIBUTIONS

D. Yadav performed literature review, data collection, analyzed and interpreted the data, prepared the manuscript text, and manuscript edition. H. Maheshwari performed the experiments, compiled the data and manuscript preparation. U. Chandra helped in the literature review, analyzed and interpreted the data, performed some of the remaining experiments and helped in reviewing and editing the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

ABBREVIATIONS

COVID-19	Coronavirus
Eq.	Equation
Fig.	Figure
LSTM	Long short-term memory
NaN	Not a Number or Null Value
SIR	Susceptible-Infectious-Recovered
UK	United Kingdom
USA	United States of America
USA	United States of America
WHO	World Health Organization
Yhat	Actual Predicted value

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AUTHOR (S) BIOSKETCHES

Yadav, D., Ph. D. Candidate, Research Scholar, Department of Computer Science and Technology, Glocal University, Saharanpur, Uttar Pradesh, India. Email: *ydharminder@yahoo.com*

Maheshwari, H., M. Tech Scholar, Department of Computer Science and Engineering, Uttarakhand Technical University, Dehradun, Uttarakhand, India. Email: *himani_bahmah@yahoo.com*

Chandra, U., Ph.D., Assistant Professor, Department of Computer Science, Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India. Email: *uck.iitr@gmail.com*

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