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RESEARCH ARTICLE

COVID – 19 OUTBREAK ANALYSIS ON THE BASIS OF MACHINE LEARNING

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Abstract

Hand gesture is language through which normal people can communicate with deaf and dumb people. Hand gesture recognition detects the hand pose and converts it to the corresponding alphabet or sentence. In past years it received great attention from society because of its application. It uses machine learning algorithms. Hand gesture recognition is a great application of human computer interaction. An emerging research field that is based on human centered computing aims to understand human gestures and integrate users and their social context with computer systems. One of the unique and challenging applications in this framework is to collect information about human dynamic gestures.

Keywords: Covid-19, SIRD model, Linear Regression, XGBoost, Random Forest Regression, SVR, LightGBM, Machine learning, Intervention.

Introduction

A disease spreading rapidly to a large population within certain region in limited span of time is referred to as an affecting a huge number of persons worldwide, then it is termed as pandemic.

COVID-19 is a severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) (Huang *et al.*, 2020). In December 2019, the first case was reported in Wuhan, China. World Health Organization declared this as a public health emergency of international concern on 30th Jan, 2020 and as a pandemic on 11th Mar, 2020

(WHO Director-General's opening remarks at the media briefing on Covid-19, 11 March 2020). WHO admitted the spread of the virus through the air under specific conditions on July 07, 2020(Transmission of SARS-CoV-2: implications for infection prevention precautions). While the Covid-19 vaccine advancement is complete but even after its successful development, the fabrication and transportation can be very challenging.

India was rather fast than some other counties in tackling the disease as soon as it started spreading on a large scale. A curfew followed by a national lockdown till May 31,2020. After then the unlocking phase began. During this, the administrations are continued in a staged way that is the partial lockdown and the country went on to being completely functional soon enough. But with the services resumed, a spike was again observed with rising cases as a second wave of Covid-19.

One of the key measures to check the Covid-19 span and lessen new Covid-19 cases is epidemiological interventions. Coronavirus circulates through interaction with contaminated person within close proximity. Vulnerable individuals may get close to a Covid-19 contaminated individual at the workplaces, educational institutions, congested public spots like social occasions, etc. The spatial distance between the people decides the chances of getting disease. Individual behavior such as social-distancing, sanitization, etc. plays a critical part to restrict the disease from spreading further. Individual measures play a vital role in saving people from disease. On account of contamination, self-confinement, keeping up actual social separating, and looking for clinical guidance are useful when the manifestation shows up.

Epidemiological models assist us with understanding the spread elements of such illnesses. Brief and extended- haul expectations for the diseases could be drawn out using these models, which might further be utilized in dynamic to improve potential controls from the illness. In narrative, various mathematical models have been instituted for such diseases. Categorization of such models begin from network

(Calafiore *et al.,* 2020) and collective models, Logistic (Turner Jr, *et al.,* 1976), general growth (Chowell, 2017; Richards, 1959) sub epidemics wave (Chowell *et al.,* 2019) One of the collective models is the SIRD model. It is a compartmental model with closed populace and categorized into 4 compartments namely susceptible, infected, recovered as well as deceased. Introduction of several contaminated individuals to this populace is responsible for contaminating other people at rate µ0, basic reproduction number.

In Recent Times, a few works have been accounted for using different mathematical models to predict the outbreak of cases at various periods. Among them, (Das, 2020) using statistical machine learning has Ro and has further made predictions for India. (Ndiaye et al. 2020) has done an analysis on the Covid-19 using SIR model and have further compared the verified cases using two different approaches and studied them. A brief analysis on SIR model with intervention has been done by (Hanuman Verma et al., 2020) who find the rate of transmission using regression techniques in their approach.

Here, the impact of intervention on SIRD model is presented by us and proposition of a new model “SIRD model with intervention” to contemplate the spread of the disease in our country and, likewise suggested an efficient way of calculating the rate of transmission (ß), recovery rate(ɣ), Death rate (µ) from the prevalent data regarding coronavirus cases. The effect of various intervention degrees is also shown. We additionally depict a forecast of coronavirus infected and recuperated cases for India, Italy and Russia till 31, Jan, 2022.

SIRD

The SIRD (Susceptible-Infected-Recovered-Deceased) tells us the spread dynamics of an infectious disease to people during a cycle. The

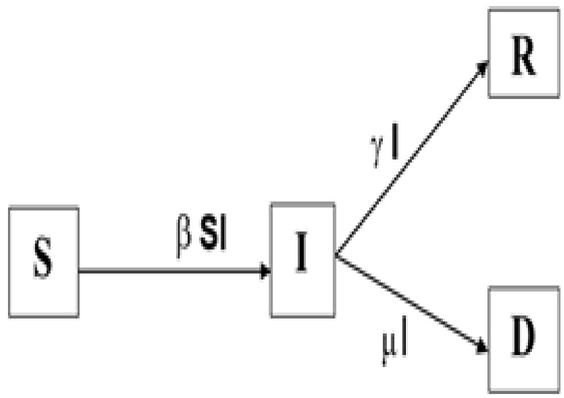


Figure 1: Compartmental SIRD model.

whole population size (N) here is constant and divided into 4 compartments namely Susceptible (S), Infectious (I), Recovered (R) and Deceased (D) varying with time (t). Fig.1 shows the people comprising N may advance to separate compartments which results in change in parameters ß, ɣ and µ.

The following set of equations are applied to define the SIRD model:

where:

S(t): Frequency of susceptible persons I(t): Frequency of infected persons R(t): Frequency of recovered persons D(t): Frequency of deceased persons ß: Transmission rate of sickness.

$$dS/dt = -\beta S(t)I(t)/N$$
$$dI/dt = \beta S(t)I(t)/N - (\gamma + \mu)\, I(t)$$
$$dR/dt = \gamma\, I(t)$$
$$dD/dt = \mu I(t) \qquad \text{Eq. (1)}$$

ɣ: Recovery Rate of sickness µ: Death rate from sickness Also, we know that S + I + R + D = constant = N.

Each susceptible person contacts ß individuals each day with a small portion I/N which are irresistible, and ßSI/N move from the susceptible to the infected compartment. The recuperation pace (ɣ) results in ɣI moving out of the I group to R group.

Essentially, (µ) pace of death results in µβ move out of the I and go to the D compartment. Ro= ß⁄ɣ+µ known as reproduction number indicating number of new contaminations through solitary contaminated individual belonging to a populace where each individual is vulnerable. On the off chance that Ro = 1, one contaminated individual taint a normal of one individual that is the spread of sickness is steady, and Ro = 2 methods a solitary tainted individual taints a normal of two individuals. In the event that Ro< 1 this demonstrates one contaminated individual taint on less than one individual and spread of illness is required to stop, and if Ro> 1 this implies a tainted individual taints on normal more than one individual and spread of

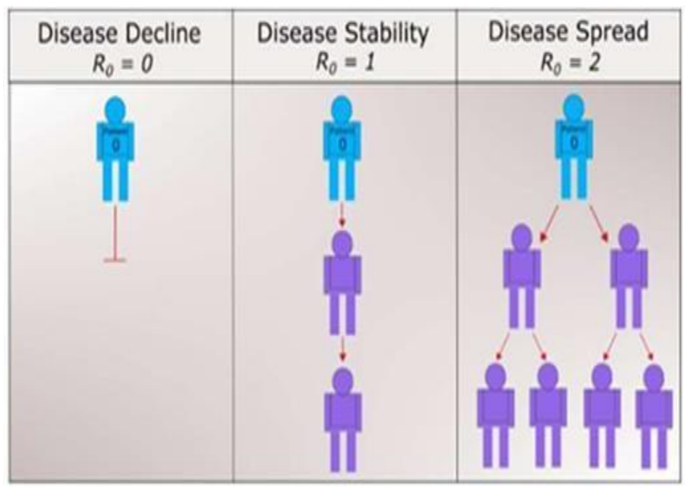
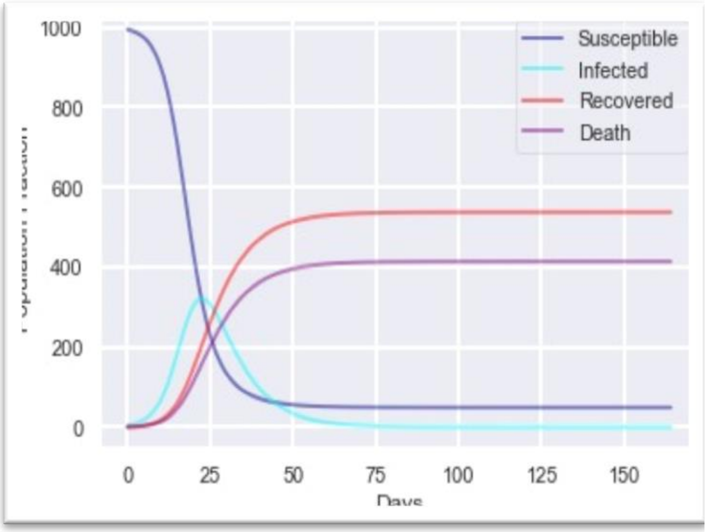


Fig. 2: Demonstration of R_0 and infectious disease spread.

sickness is expanding without intervention. It is demonstrated in Fig. 2.

The SIRD model attempts to anticipate the number of infected people or term of spread of the illness. In this model, the computation of Ro= ß⁄ɣ+µ is an exceptionally difficult assignment for extraordinarily Covid-19. The rate of recovery of this irresistible sickness is generally estimated two weeks. Here, value of 1⁄ɣ = 14. In section 4, the estimation of rate of transmission (ß) has been discussed for thereby deciding Ro.



In above graph, SIRD model having an example populace of 1000 then firstly introducing five contaminated people. At time t = 0, N = 1000, I (0) = 5, R (0) = 0, D (0) = 0 and S (0) = N−I (0)–

R (0)–D (0). Allow the transmission rate ß = 0.40 and mean recovery rate ɣ = 1/14 (1/days) and μ = 1/18, which infers the essential propagation number Ro= 3.15. Fig. 3 shows all the different compartments of the SIRD model.

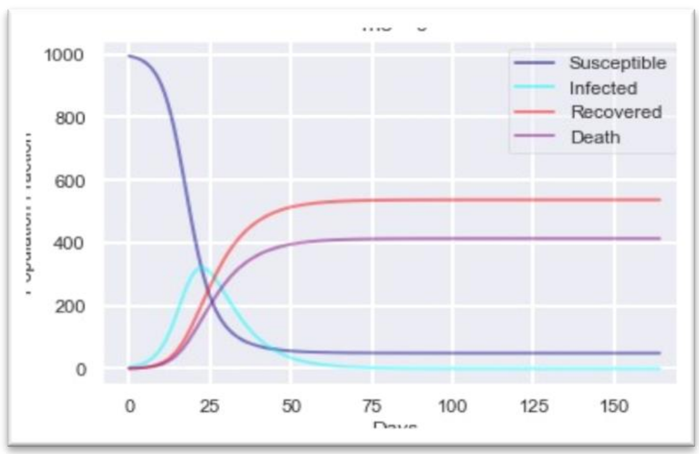
At first, susceptible curve decline gradually that might be the formulating time of sickness. It diminishes quickly following two weeks representing people moving out of S class to I class. Cyan bend represents these individuals. At first, only 5 individuals were introduced in the shut populace making Ro= 3.15, soon infecting in excess of 335 people every day at the end of 22 days, forming curve's peak. The red curve represents people moving from I class to R class. The quantity of recovered individuals increments when contrasted with contaminated individuals can be observed after 25 days. The deceased curve (purple) is similar to recovered curve (red) but its values are less in number.

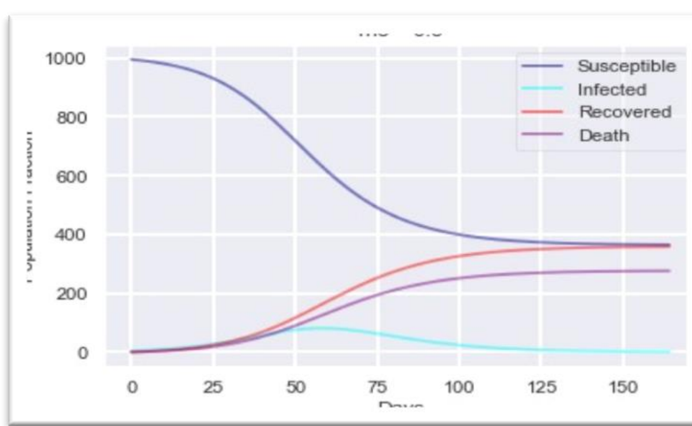
SIRD with intervention

As we examined over that in traditional SIRD model, the entire populace is shut and is without any interventions like lockdown, social-distancing, isolate, and so on. In the old model, just transmission rate ß is thought of. In any case, the intervention factor influences the transmission rate as well. Assuming in the shut populace, if 5 (I (0) = 5) people being contaminated with the Covid-19 and promptly these 5 tainted people tried positive and have been isolated from the whole populace, at that point no other individual will get the contamination from them and the sickness may vanish rapidly. A factor (1 – ρ) is introduced along with the rate of transmission (ß) where intervention factor (ρ) is merged to the classical model. Below equations represent the SIRD model with intervention: ρ lies between [0,1]

where 0 stands for no intervention and 1 for complete intervention. Assuming, ß = 0.40, ɣ = 1⁄14, μ = 0.55 and N = 1000, I (0) = 5, R (0) = 0, D (0) = 0 and S (0) = N− I (0) − R (0)– D (0).

Fig. 4 Demonstrates the model with different values of ρ and its graphical representation





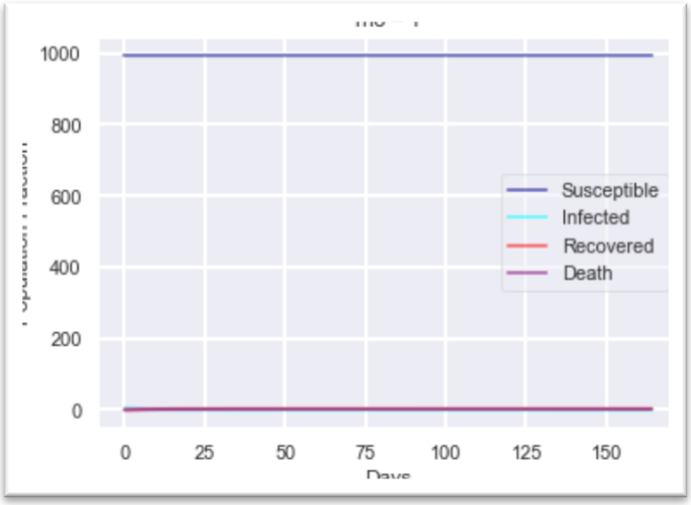


Fig 4: SIRD model with intervention for different value of (a)$\rho = 0$, (b) $\rho = .5$, (c) $\rho = 1$.

When $\rho = 0$, the graph lessens to traditional SIRD model comprising similar boundaries (Fig. 4(a)). On account of $\rho = 1$, $(1 - \rho) = 0$, therefore we get S(t) = constant, which is shown in Fig. 4(c) which portrays the susceptible cases getting consistent. Be that as it may, for $\rho = 0.5$, at 50 μh day we witness the highest infected cases per day i.e. 93, and sickness will vanish in 162 days. We can obviously perceive how even modest quantity of intervention hindered the spread of the infection. The goal of disease transmission experts is to help the public authority's policymakers, limit the fresh coronavirus cases and defer pinnacle of the disease, assisting us in dealing with the medical facilities and financial exertion at the controllable levels giving us time to sit tight for comprehensive antibody fabricating and immunization of whole country.

Rate of transmission, rate of recovery and death rate using prevelance data using various regression model

As we are as of now mindful that computation of transmission rate (ß) is a difficult undertaking. Along these lines, to assess ß, prevalent coronavirus data of the country has been contemplated by us. Deterministically, dI/dt can be composed as $\Delta I/\Delta t$, where $\Delta I(t) = I(t+1) - I(t)$ and $\Delta t = (t+1) - t$ days. Here I(t) is the aggregate number of infected individuals in the period $\Delta I(t)$ is is contaminated people each day.

With the help of Eq. (1):

Rate of transmission (ß)

$$dI/dt \approx \Delta I/\Delta t = \beta\, S(t)I(t)/N - (\gamma + \mu)\, I(t) \qquad \text{Eq. (3)}$$

Simplifying further, we get

$$\beta = ((\Delta I(t)/\Delta t) * 1/I(t) + \gamma + \mu)N/S(t) \qquad \text{Eq. (4)}$$

We have implemented 5 different regression model to calculate the accurate value of ß. These are: Linear Regression, XGBoost, Random Forest Regression, SVR, LightGBM.

We have taken the Mean Square Error for finding the best regression model to get the value of ß from.

Rate of Recovery (ɣ) and death rate (μ)

$$dR/dt = \gamma I(t) \qquad \text{E.q= 5}$$

$$dD/dt = \mu I(t) \qquad \text{E.q = 6}$$

We have implemented 4 different regression models to calculate the accurate value of ß.

These are: Linear Regression, XGBoost, Random Forest Regression, LightGBM.

Assessment of ß, ɣ, and μ are done with 10 cross- validations to track down the ideal value using the programming language Python.

Dataset

- ***India:***

The coronavirus information is acquired by us using Covid- 19India.org [14] from August 27, 2021, to October 31, 2021. The quantity of verified, recuperated, and expired cases for India and all of its regions are freely accessible at Covid-19India [14]. It is easily accessible on the web being a publicly supported open data set:

COVID19-India API | data

- ***Italy:***

The coronavirus information is acquired by us using Presidenza del Consiglio dei Ministri - Dipartimento della Protezione Civile (github.com)- [14] from August 27, 2021, to October 31, 2021. The quantity of verified, recuperated, and expired cases for Italy and all of its regions are freely accessible at [15]. It is easily accessible on the web being a publicly supported open data set:

pcm-dpc/COVID-19: COVID-19 Italia - Monitoraggio situazione (github.com)

- ***Russia***

The coronavirus information is acquired by us using https://www.statista.com/ [14] August 27, 2021, to October 31, 2021, The quantity of verified, recuperated, and expired cases for Russia are freely accessible at https://www.statista.com/ [16]. It is easily accessible on the web being a publicly supported open data set:

• Russia: coronavirus cases | Statista

Validation and forecasting

Here, we approve the tests utilizing our model through verified information. Assessment of rate of transmission ß, γ and μ with the help of prevalent data. The contaminated and recuperated populace have been validated by us in our model for certain provinces of the country. Python with Panda [16] was used to obtain the results, which are examined in the accompanying subsections.

- ***Estimating rate of recovery (γ):***

In this examination, we have assessed the worth of μ with the assistance of pervasive revealed coronavirus information in India for the span starting August 27, 2021, to October 31, 2021. Utilizing Equation (5) calculation of μfor 65 days has been done by us and afterward determined μ utilizing supervised ML techniques.

(a) India:

Models	Value	Mean Square Error
Linear regression	0.097336	**0.000154**
Random Forest	0.097076	**0.000178**
LightGBM regression	0.097338	**0.000149**
XGBoost regression	**0.09689**	**0.000183**

(b) Russia

Models	Value	Mean Square Error
Linear regression	0.0288320	**1.807233**
Random Forest	0.02892	**2.1080266**
LightGBM regression	0.028837	**1.558277**
XGBoost regression	**0.0289424**	**1.767204**

(c) Italy:

Models	Value	Mean Square Error
Linear regression	0.046241	**0.0001287**
Random Forest	0.046530	**0.00020150**
LightGBM regression	0.0462642	**0.00012934**
XGBoost regression	**0.0466620**	**0.00017902**

- **Estimating rate of death (μ):**

In this examination, we have assessed the worth of μ with the assistance of pervasive revealed coronavirus information in India for the span starting August 27, 2021, to October 31, 2021. Utilizing Equation (6) calculation of μ for 65 days has been done by us and afterward determined μ utilizing supervised ML techniques

(a) India:

Models	Value	Mean Square Error
Linear regression	0.00127606	**8.7195667**
Random Forest	0.00127686	**4.42230**
LightGBM regression	0.0012783	**9.0186039**
XGBoost regression	**0.00127764**	**4.1098671**

(b) Russia:

Models	Value	Mean Square Error
Linear regression	0.00136157	**1.057949**
Random Forest	0.00136237	**1.0050922**
LightGBM regression	0.00136172	**2.110418**
XGBoost regressio n	**0.00136151**	**4.1715881**

(c) Italy:

Models	Value	Mean Square Error
Linear regression	0.00047024	**1.719009**
Random Forest	0.00047297	**2.7582842**
LightGBM regression	0.0004704	**1.7554220**
XGBoost regression	**0.0004700**	**1.7462143**

- **Estimating rate of transmission (ß):**

In this examination, we have assessed the worth of ß with the assistance of pervasive revealed coronavirus information in India for the span starting August 27, 2021, to October 31, 2021. Utilizing Equation (4) calculation of ß for 65 days has been done by us and afterward determined ß utilizing supervised ML techniques.

(a) India:

Models	Value	Mean Square Error
Linear regression	0.1901175	**0.00030225**
Random Forest	0.1902928	**0.0003805**
svr regression	0.179419	**0.0004695**
LightGBM regression	0.190187	**0.0003114**
XGBoost regression	**0.18996726**	**0.0004488**

(b) Russia:

Models	Value	Mean Square Error
Linear regression	0.071756	**3.1939**
Random Forest	0.071861	**2.71263**
svr regression	0.071574	**4.3254**
LightGBM regression	0.071796	**2.417934**
XGBoost regression	**0.07192316**	**2.67302**

(c) Italy

Models	Value	Mean Square Error
Linear regression	0.0926104	**0.0004654**
Random Forest	0.0931564	**0.0006419**
svr regression	0.0877433	**0.0004325**
LightGBM regression	0.0926584	**0.0004423**
XGBoost regression	**0.0933866**	**0.0006171**

Estimated ß, **γ** and □ value and Intervention ρ.

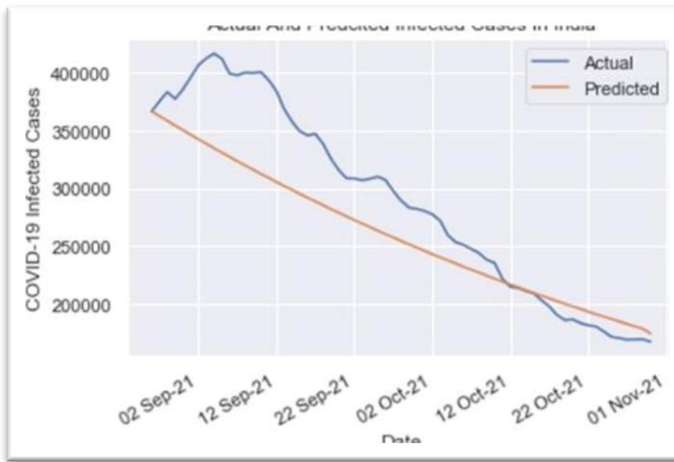
Country	ß	γ	µ	ρ
India	0.1901175	0.09733	0.00127	**.53**
Russia	0.071796	0.0288	0.001362	**.46**
Italy	**0.087743**	**0.04624**	**0.00047**	.53

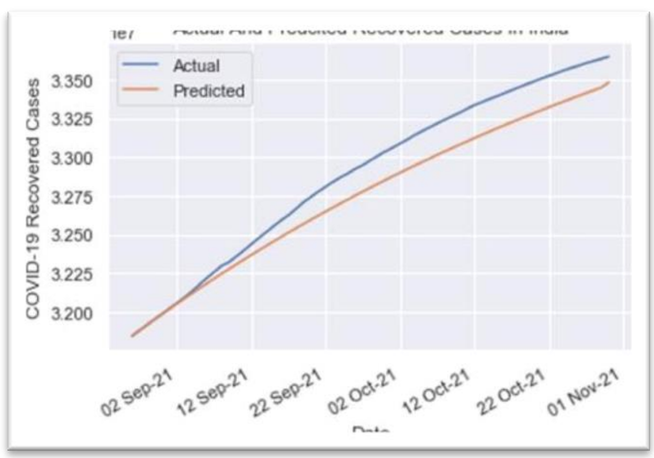
The values of ß, **γ** and µ are taken from results gathered after using different regression algorithm(Linear Regression, XGBoost, Random Forest Regression, SVR, LightGBM) and choosing the most accurate of those by using mean square error method. These algorithms are used on the already present data for the time duration of 27 Aug 2021 to 31 Oct 2021. By using the factors, we have gathered from above experiment be will be predicting the covid-19 cases from 31 Oct 2021 to 31 Jan 2022.

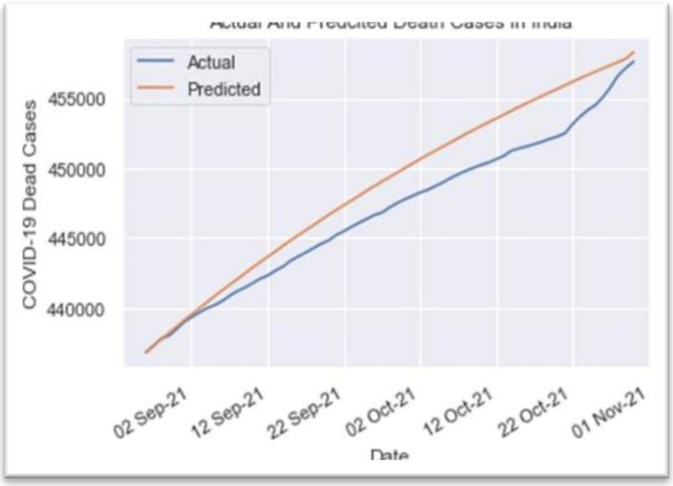
Validation and forecasting

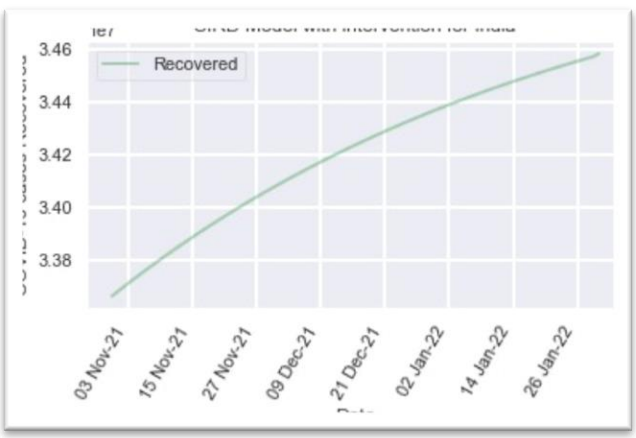
India

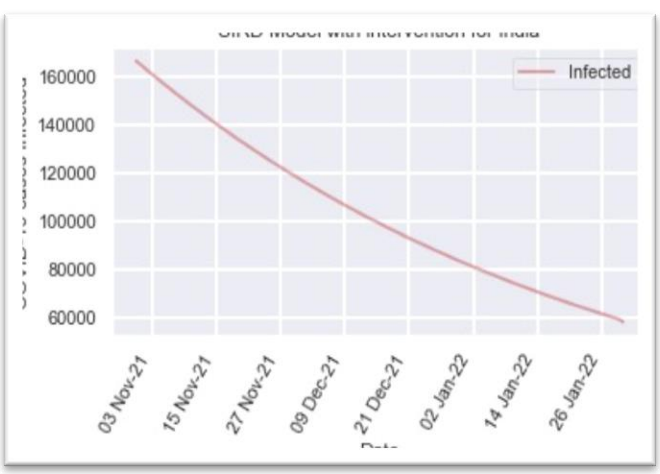
India is ranked 2nd in terms of confirmed cases across the world till now. The value of ß comes out to be 0.1901, ρ = 0.53, ɣ = 0.09733 µ = 0.001277 for the model using Covid-19 prevalent information. We validate actual and predicted cases, as shown in Fig. 7. We observe that both real and anticipated bends. Further, utilizing similar boundaries, we anticipate the quantity of tainted and recuperated cases for India till Jan 31 2022, appeared in Fig. 8. As per the current situation, India will observer 58,100 Covid-19 Infected cases, 3,54,82,310 recovered cases and 4,69,974 Death cases till Jan 31 2022.

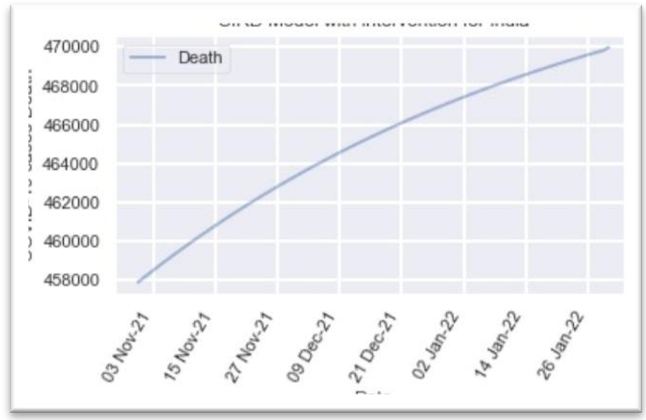








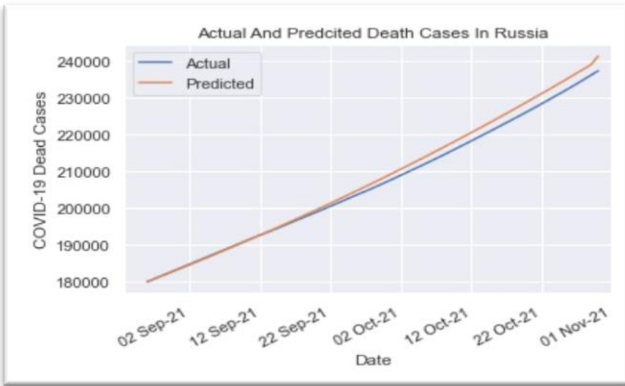


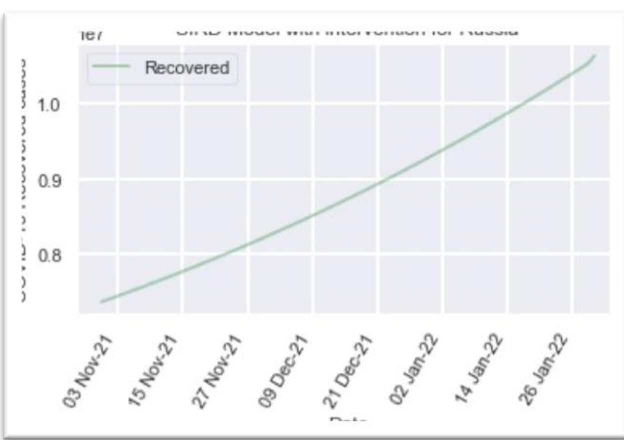


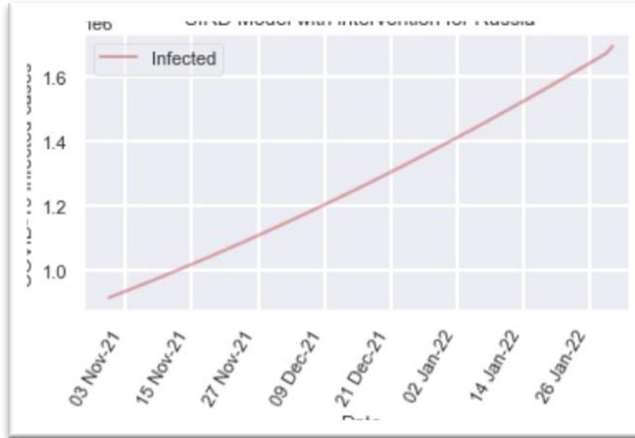
Prediction of Covid -19 cases for India

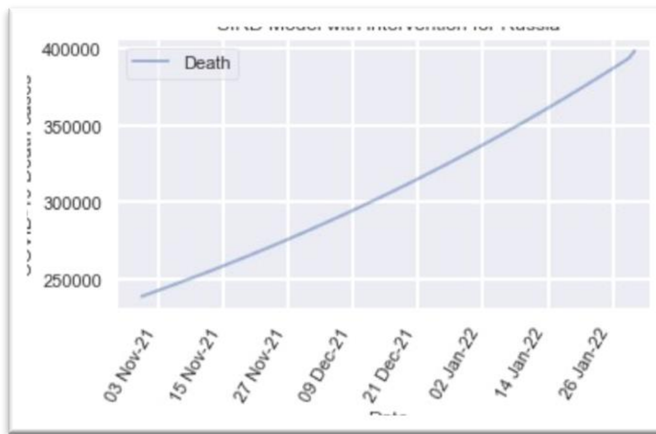
Russia

Russia has the highest COVID-19 death toll of any European nation, with 218,345 fatalities. The country has reported 7,832,964 cases of the disease since the start of the pandemic. The value of ß comes out to be 0.0717966, ρ = 0.47, ɣ = 0.0288 µ = 0.00136 for the model using Covid-19 prevalent information. We anticipate the quantity of tainted and recuperated cases for Russia till Jan 31 2022, appeared in Fig. 10 As per the current situation, Russia will observe 16,90,430Covid-19 Infected cases, 1,06,42,372 recovered cases and 3,98,095Death cases as on Jan 31 2022.





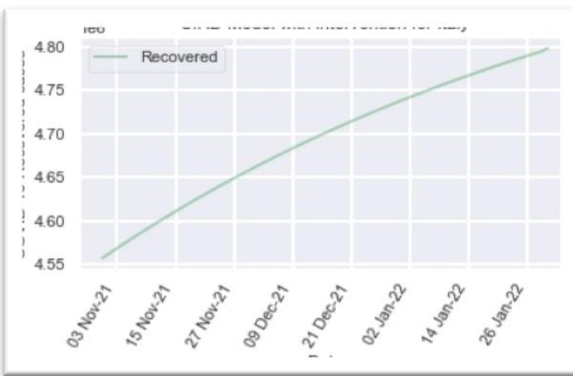


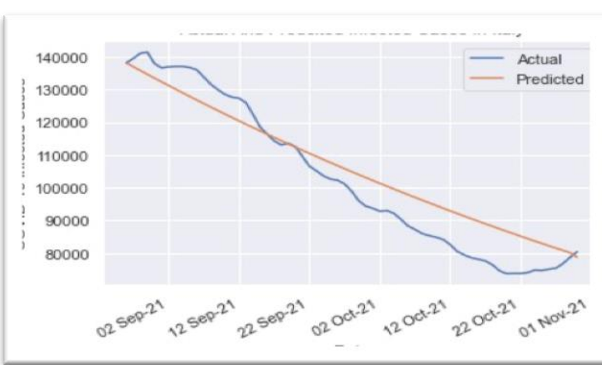


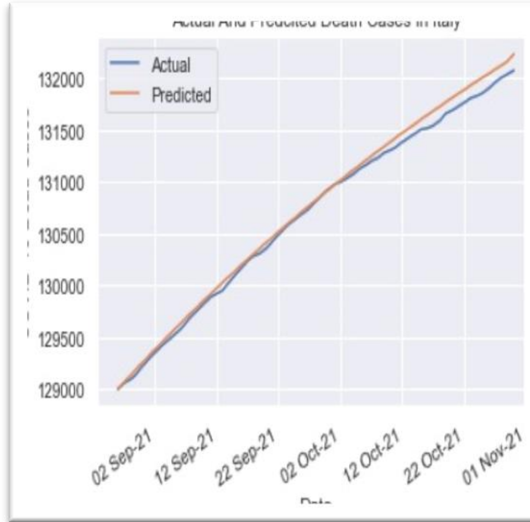
Prediction of Covid -19 cases for Russia

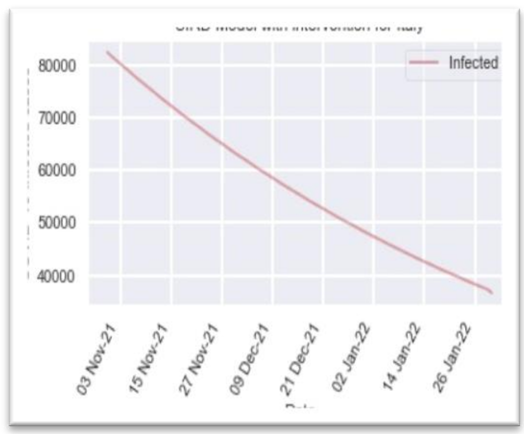
Italy

Italy was the first European country to face surge in COVID cases in April 2020. In Italy, the first two cases of coronavirus (COVID-19) were registered at the end of January 2020. Then, since February 22, the virus started to spread quickly among the Italian population. As of October 14, 2021, Italy recorded 4.7 million cases of coronavirus (COVID-19), representing one of the most affected countries worldwide. Currently, the regions with the highest number of cases are Lombardy, and Veneto, located in the north of the country, followed by Campania, in the south. Demographic data on the infected patients show that COVID-19 in Italy has hit every age group uniformly. However, the mortality rate appears to be much higher for elderly patients. Nationwide, 4.5 million people recovered from coronavirus or were discharged from hospitals as of October 14, 2021.We anticipate the quantity of tainted and recuperated cases for Italy till Jan 31 2022, appeared in Fig. 12 As per the current situation, Italy will observe 36,663 Covid-19 Infected cases, 47,98,013 recovered cases and 1,34,546Death cases as on Jan 31 2022.









Prediction of Covid -19 cases for Italy.

Conclusion

Even after the development of vaccines, Covid-19 disease is a genuine danger because of its quick spreading conduct. In view of inadequate health services and an extremely thick populace of India, the disease should be considered very intimidating. We have already established that just the introduction of vaccines is not enough, and vaccination of entire population will take time. Therefore, epidemiological interventions would help control the spread of disease until it dies out eventually. Remembering this, a new and improved model has been recommended by us in this work merging the traditional SIRD with intervention. We have also demonstrated an efficient way for estimation of (ß) for the model with the help of prevalent information in India. Code of the work is carried out and executed in Python and further forecasts of active and recuperated cases in India, Russia and Italy till 31 Jan 2022. The vaccination of people has severely impacted the curves and the predicted data may differ because of govt imposed interventions and other factors such as personal behavior and awareness. Currently, no vaccine is 100

% effective and there are cases when people getting infected even after vaccination.

We close our examination in after focuses:

- The flattening of the Covid-19 spread bend has only been possible because of different interventions.
- Interventions such as vaccination, social-distancing, sanitization and isolation are vital to fight Covid-19 until the vaccination of entire country is complete.
- Though, we have come a long way from where we were in mid-2021, there is as yet a requirement for speed increase in following, vaccination, testing and confining individuals. Also, treatment of people should commence at beginning phase of the disease especially at remote locations as well as some metropolitan zones thereby, growing ρ results in decrementing of the rate of transmission ($\text{ß}(1-\rho)$) bringing about a decrease in contaminated people.
- The predicted values may not be as accurate since different governments are imposing different lockdown in their countries amid Covid cases. Also, vaccination, social distancing, quarantining, and personal behavior are some of the other factors which may be responsible for disparities in future predictions.

Reference

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