Computer Methods in Biomechanics and Biomedical Engineering: Imaging & Visualization

https://www.tandfonline.com/journals/tciv20

Accepted August 31st 2022

PREDICTIVE ANALYSIS OF COVID 19 DISEASE BASED ON MATHEMATICAL MODELLING AND MACHINE LEARNING TECHNIQUES

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ABSTRACT: During the emergence of a novel pandemic, predictive modelling process is more important in the phase of public health planning and response. Relating models to data provides a view into unseen variables, such as the occurrence of cryptic transmission and the prevalence of infection. These models allow exploration of counterfactuals and hypothetical interventions. However, although there have been tremendous advances in mathematical epidemiology, prognostications about epidemic outcomes are inherently prone to errors. Predictive modelling is a valuable model based on the clear definition and estimation of the variables. Researchers or policy makers who use the model outputs have a clear understanding of what can and cannot be achieved by this method. The results of this study are suggested that substantially more cases were present in many countries than were reported in the official statistics. In this paper we have identified the potential discrepancy between reported cases and true disease burden provided a crucial early warning to the international community. In this research paper we proposed statistical modelling and data-driven computer simulations provided accurate projections of global epidemic dispersal, quantifying the role of physical distancing in places and reductions in international travel on the spatiotemporal pattern of spread of COVID-19 based on Linear regression analysis.

Keywords: *Predictive Modelling, Covid-19, Linear regression model, Statistical model.*

1. INTRODUCTION:

Indeed, calls for national disease-forecasting centres have arisen from the crucial need to educate policy makers at all levels on how to integrate predictive modelling into decision-making processes. Deriving insights with predictive modelling requires diverse datasets, which are often imperfect, particularly in the crucial period of epidemic emergence when surveillance is imprecise and little is known about the epidemiology or the clinical features of the disease. For example, extensive clinical case counts and genomic data were combined with large-scale records of human mobility and behaviour using predictive modelling, owing in part to the massive deployment of digital information sources. In this Comment, we have highlighted several important discoveries resulting from the application of predictive modelling to diverse data sources that affected clinical and policy decisions. In the following the first report of COVID-19, predictive models anticipated the pattern of international spread but also quantified the extent of the epidemic in China. Specifically, a predictive model by Imai and colleagues used travel volumes from Wuhan and the dates when imported cases first arrived in cities within China and globally to forecast the size of the epidemic in Wuhan. The results of this study suggested that substantially more cases were present in Wuhan than were reported in the official statistics. We are identifying the potential discrepancy between reported cases and true disease burden provided a crucial early warning to the international community.Next, statistical modelling and data-driven computer simulations provided accurate projections of global epidemic dispersal, quantifying the role of physical distancing in Countries and reductions in international travel on the spatiotemporal pattern of spread of COVID-19.

These predictive models showed that the cordon sanitaire around countries reduced the growth rate of exported cases but came too late to prevent national and international seeding [1]. Control of the epidemic in countries outside China failed because of the difficulty in detecting and isolating infected travellers. Mechanistic modelling of the natural history and transmission of COVID-19 anticipated this difficulty. A predictive model provided the first evidence for the hypothesis, now widely accepted, that presymptomatic and asymptomatic infected individuals fuel local epidemics.Consequently, the majority of imported cases went undetected, generating extensive chains of local transmission. Owing to the difficulties of syndromic surveillance and incomplete testing, COVID-19 mortality has often been the most easily measured, widely available, and easily compared metric for epidemic progression. Estimates of infection fatality rates are generated by early studies of expatriated travellers paved the way for later efforts to characterise unknown epidemic burden using various modelling approaches that relate mortality to unknown epidemic prevalence[2].public health measures on the amount of human contact and geographical extent of travel. Aggregated data from mobile phone and internet service records provided an accurate and near real-time information source. By leveraging these data, predictive modelling allowed for the assessment of mobility restrictions on the propagation of the epidemic and showed how control measures implemented in China substantially mitigated the spread of COVID-19.6,7 As the pandemic progressed and lockdowns were implemented in many countries, analyses based on mobile phone records provided essential support to public health assessments across the different stages of lockdown implementation and release.8 According to Google Scholar, there have been well over 30000 academic publications with COVID-19 in the title. Of these 30000 papers, less than 2% indicate from the title that they use predictive modelling. Nevertheless, nearly every business, hospital, city, state, and national government has been provided with COVID-19 forecasts. This disconnect between the small but rapidly growing science around outbreak forecasting and its now widespread application creates a complex situation for researchers, clinicians, and policy makers. As a result, we echo calls for disease-forecasting centres at the national level that provide not only predictive models but also expert guidance to policy makers and the public around the interpretation of the models. We concluded that predictive modelling is not a monolithic framework nor a single methodology but rather encompasses a wide variety of statistical and mathematical models are applied to diverse data to address different inference and prediction goals.

MOTIVATION: Data science helps to analyse the data for simulation and patterns imagine of coronavirus spreads by including daily reported patients with coronavirus infected cases.Data analytics helps to gain some valuable of datainsight.Machine Learning makes create models and predictions that mapping the real world of some data and predicting the future purpose[16]. So, in this proposed model,First we have to try to imagine data and then forecast future data .We have also focused on to find the best fit regression model that can do future predictions.

Already in this century, several global epidemics have broken out (bovine spongiform encephalopathy, avian influenza, severe acute respiratory syndrome (SARS), etc.). The latest coronavirus epidemic (CODIV-19) struck everyone with its scale and affected literally all countries forced to take emergency measures to prevent the infection spread of (closure of state borders, quarantine, self-isolation, temporary work break of many enterprises and institutions, transition to distance work and training). The number of people infected in the world exceeds 4.89 million people (the data from end-May 2020), and the number of deaths is more than 320,000 people.

The main difficulty in applying mathematical models is associated with the uncertainty of the choice of coefficients in the equations. The more complex is the model, the larger is the number of its coefficients. The experience of using models to interpret “old” epidemics may not always help, since the intensity of the virus impact on living organisms changes, many epidemics were local, and, accordingly, measures to prevent the epidemic spread were different. The pattern of the curves shown in below figures, shows their strong differences for different countries, which is associated with different population density, differences in their customs, traditions and administrative preventive measures.Therefore, any forecasts at the initial stage of the epidemic development regarding its final stage are very rough and unreliable. As the epidemic develops, more and more constants in the equations can be determined from medical databases, but the previous constants are also corrected.Therefore, in essence, for prognostic purposes, equations with variable coefficients are solved, which mathematical properties (existence, convergence and stability) are not defined. As a result, different models with permanently “corrected” coefficients can lead to close forecast results for a short time. At the same time, for long-term forecasts, it is necessary to understand the possible temporal variability of the model coefficients, and their influence on the character of the obtained solutions.

The contribution of the paper as follows:

- We have applied Mathematical model for predicting the Covid 19 cases in real world.
- We have analyzed data for simulation and patterns of Covid 19 cases.
- We have taken data randomness on the number of cases per day, it is proposed to switch to a stochastic logistic equation with external force.

The paper is organized as follows

Section 2 describes literature survey, Section 3 provides the Proposed methodology. Section 4 presents experimental analysis and results. Section 5 gives conclusion.

2. LITERATURE SURVEY:

General information about this viral infection can be found on the Internet. The dynamics of the disease spread is illustrated in the growth in the number of coronavirus cases in the world and in several countries is indicated in a semi-logarithmic scale. The dashed lines show exponential asymptotics corresponding to doubling the number of cases in a certain number of days. Asterisks indicate the days when countries introduced restrictive measures. As one can see, the nature of the epidemics spread in each country follows almost the same scenario, first there is an exponential growth (or close to exponential) of the number of infected people, and then this growth slows down (however, the numerical values of the constants describing these curves are different for different countries). In some countries, the number of cases is no longer increasing, so the coronavirus epidemic in these countries is almost over. In other countries, the curves in these coordinates are still almost straight lines,which means an exponential increase in the number of cases, and the epidemic has not yet reached its peak. In general, these curves are quite smooth, although some of them show bends associated with the action of certain quarantine measures.

Donnellyetal have to focus to estimate the potential total number of novel Coronavirus (2019-nCoV) cases in Wuhan City[23].Chinazzi M et al have been focused on the effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. Pinottietalhave been focused on Tracing and analysis of 288 early SARS-CoV-2 infections outside China: Hellewell J, Abbott S, et al[26] provides the feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. Flaxman S.et al.to estimate the effects of non-pharmaceutical interventions on COVID-19 in Europe[27].

Machine learning plays an important role in better understanding and studying the COVID-19 crisis, as it identifies patterns of data and uses them to make predictions and decisions automatically. In the field of medical services, machine learning can be seen as an asset with extensions for processing large datasets beyond the capabilities of human personality, and the insights gained from this can be organized by physicians. Helps explain how to be accepted process. Based on this concept, this study was conducted on the analysis of COVID-19 cases and the prediction of new positive cases in the future [29]. In this model, the author looks at the confirmed evolution of the coronavirus, the reduction and recovery of cases worldwide, and a comparison of five countries that have been severely infected in other parts of the world.

Dong Je et al. , (2020) introduced a model to elucidate the risk factors for coronavirus. They collected clinical data from all patients admitted to Fuyang Second People's Hospital in China between January 20th and February 22nd, 2020. They divided about 208 patients into two categories-a stable group and a progressive group. Univariate and multivariate analysis reveals autonomic risk factors for COVID-19 Movement. They concluded that using the CALL score model could be an effective resource for addressing this challenge [14]. Weston C Roda et al. , (2020), after comparing the SEIR and SIR models, summarized that a complex model like SEIR does not need to be more effective than a simple model SIR. They use the Bayesian framework, the Markov chain Monte Carlo algorithm, Akaike's Information Criterion (AIC).C Sohrabi et al. , 2020 [30] reports that as of December 31, 2019, few cases of coronavirus have been confirmed in China. WHO Global Health Emergency, Global Response, Reported UK Cases and Responses, Infection, Virus Spread, Prevention, Diagnosis, Treatment, Prognosis The containment method for this virus has been addressed by the author. The authors also compared the CDC diagnostic criteria with the WHO diagnostic criteria based on symptoms and travel. In the treatise, the author also described a retrospective exhibition of the response to COVID-19. R. Khan et al. , 2020 [31] is investigating sentiment analysis techniques for the analysis of Twitter Covid-19 data. They found that pre-processing information using regular expressions and coaches was a viable solution to eliminate the unpredictability of applied calculations and information. Rather than referencing the rough information itself directly. By using the created model and further by using it in a classifier, the time and size of the information structure is reduced, and the temporal unpredictability associated with that number of cycles is reduced, resulting in grouping. This is a good method. Consistent about tweets shared by dynamic customers It becomes clearer when compared with various evaluations this Means the largest number of people in relation to a pandemic Considered the decision made by the government and made it The experts around me are positive. The crowd Contaminated and destroyed individuals continued to expand, it did not It affects the psychological quality of the population. for A three-month survey related to the masses in the suburbs of India Diversity between positive, negative and impartial evaluations Keep pace with the number of expanding cases Step by step. Oliveiros, Barbara, et al. , 2020 [32] discussed COVID-19 It is expected to slow down in spring and summer. Rajarajeswari.etal focused on Machine learning approaches for human healthcare applications [34, 35].

Author name	Contribution	Methodology	Advantages
S.Duttaet al[3]	COVID-19 cases are confirmed based on Prediction models.	LSTM,GRUandcombined LSTM-GRU Model [20] were used. DeepLearningneuralnetwork also employed.	Better outcome achieved by using LSTM-GRUand RNN model.
Narinderetal[4]	AllCOVID-19stagesare described	Medicineknowledge is needed to get the societal challenges.	Medical applications are developed.
Sohiniand Sareeta etal[5]	They have used machine learning techniques for finding COVID-19 cases.	Expansion of Covid-19 confirmed deaths and recovered cases of Asian countries to different major countries that have been compared.	Graphical analysis is prepared with Gender distribution for diagnoising the Covid-19. Piecharts are used foragewisedistributio n.
Hamzahet al[6]	Corona tracker can be usedanOnlinestage.It providessolidnews advancement, of investigation on COVID-19.	They have utilized SEIIR modelling. They utilized theSEIR modelto figureCovid-19episodes inside and Outsideof Chinaand provide day to day cases	Investigations are performed on the Queried News.
LWynantsetal.,[7]	They have proposed a model for inspecting all	They proposed at high danger of covid 19 cases.	Expectations could be untrustworthy

	the papers identified with covid-19 pandemic		
R.Sujathaetal.,[5]	Datavisualization process performed by using three models for their predictions of corona in India.	Using graph plotting, they try to figure out the future trend of this epidemic.	From apprehended qualities and coordination cases from dataset information they concluded that MLP strategy is giving acceptable forecast outcomes than that of the LR and VAR technique
L.Penget al.,[8]	They depends upon gauge key plague boundaries by using SEIR model.	They made forecasts in the curvature period	24 regions of consummation time in Territory and 16 regions of Hubei region
Dryhurst, Sarah,et al[9]	COVID-19 risks are around the world identified.It is clearly shows the consistent connection betweenCOVID-19 perceptions of risk.	Socio-cultural factors across the countries.	Cultural differences in risk perception should be addressed.
Yan, Carol H., et al, 2020 [10]	Covid 19 cases are detected with ambulatory people with flu like side effects; chemosensory brokenness was unequivocally connected with COVID-19.	View for screening manifestations.	Most will recoup chemosensory work inside weeks, resembling goal of other illness related manifestations

Table 1: Related work

3. PROPOSED METHODOLOGY:

Making fast and accurate decisions are vital these days and especially now when the world is facing such a phenomenon as COVID-19, Therefore, counting on current as well as projected information is decisive for this process. In this matter, we have applied a model in which is possible to observe the peak in specific country cases, using current statistical information, hoping it can be used as foundation support to take action in this scenario[17,19]. To accomplish this objective, Non-linear regression has been applied to the model, using a logistic function [18]. This process consists of:

Data pre-processing

- Choosing the most suitable equation which can be graphically adapted to the data, in this case, Logistic Function (Sigmoid)
- Database Normalization
- Fitting of the model to our dataset using "curve fit" process, obtaining new reference beta.
- Model evaluation.

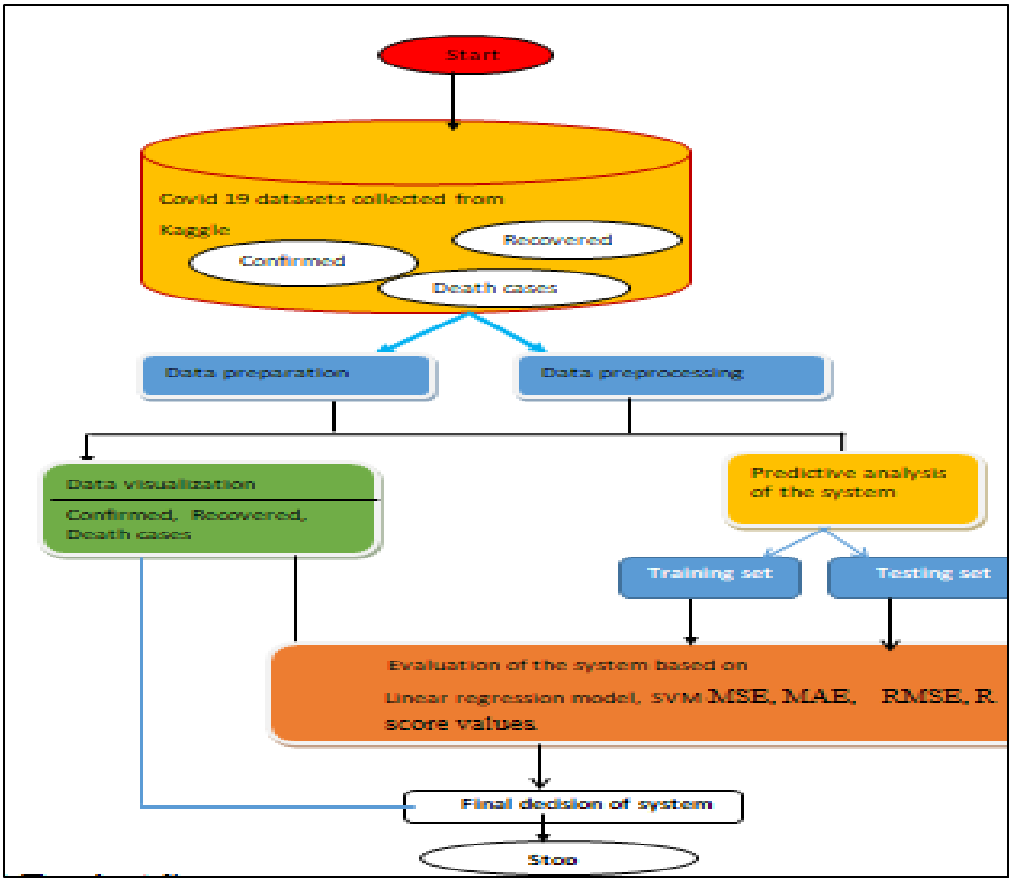

Fig 1: Flowchart diagram

Fig 1 represents the flow chart process of the system as shown above diagram. This system has Data visualization and Predictive analysis of the system. In Data visualization process, we can show Confirmed, Recovered, Death cases for different countries. In Predictive analysis of the system shows the evaluation of system based on linear regression model [3].

In this study, we will try to assess the character of the scatter of the logistic model coefficients and its generalizations on the basis of the currently available COVID-19 data. The data of the epidemic development were used for the following countries: Austria,Switzerland, the Netherlands, Italy, Turkey and South Korea. Section 4 presents the classical logistic equation and shows the calculations of the coefficient average values within this equation for the above mentioned countries. It has been shown that this model with a high determination coefficient is suitable to describe the number of patients with Coronavirus in most countries, except for South Korea. To take into account the data randomness on the number of cases per day, it is proposed to switch to a stochastic logistic equation with external force. The spectral and statistical properties of random parameters of this equation are investigated [11].

4. EXPERIMENTAL ANALYSIS AND RESULTS:

Linear Regression: - Linear regression means we need to fit all the data point in single straight line. If the data point actually on the line the loss is o. Loss is 0 means correctly classified data point. If the data point above the line or below the line some loss is there. We are try to fit all the data point in that strait line and minimize the loss and try to make it 0. In this case we use loss function as performance metric. Loss lies between 0 to infinity. Loss 0 means good and loss infinity means worst.

We will now consider a more general model of a logistic equation containing four constants

$$dN/dt=rN^{\infty}(1-N/N\infty)^{\beta} \qquad \textbf{---Eq(1)}$$

When $\alpha=\beta=1$.

We have to provide the relationship between no of cases per day(K) and total number of infected people(N),that is expressed by algebraic curve which is shown below.

$$K=rN^{\infty}(1-N/N\infty)^{\beta} \qquad \textbf{----Eq(2)}$$

It is shown that, on average, this model is suitable for all the countries listed above with a high determination coefficient.

Thus, the generalized logistic equation can be considered to be a stochastic one with time-dependent coefficients

$$dN/dt=r(t)N^{\alpha}[1-p(t)N]^{\beta}+f(t) \qquad \textbf{----Eq(3)}$$

Here we will give briefly the main information on the logistic equation theory written in the standard ODE form

$$dN/dt=rN(1-N/N\infty) \qquad \textbf{----Eq(4)}$$

Machine learning tools can be used for visualization and prediction of pattern of covid 19.The following tables provide the stastical analysis of deaths,recovered due to covid 19 for various countries[12,13].

Date	Country	Confirmed	Recovered	Deaths
2020-01-22	Afghanistan	0	0	0
2020-01-23	Afghanistan	1	0	0
2020-01-24	Afghanistan	2	0	0
2020-01-25	Afghanistan	3	0	0
2020-01-26	Afghanistan	4	0	0

Table 2: No of cases in Afghanistan

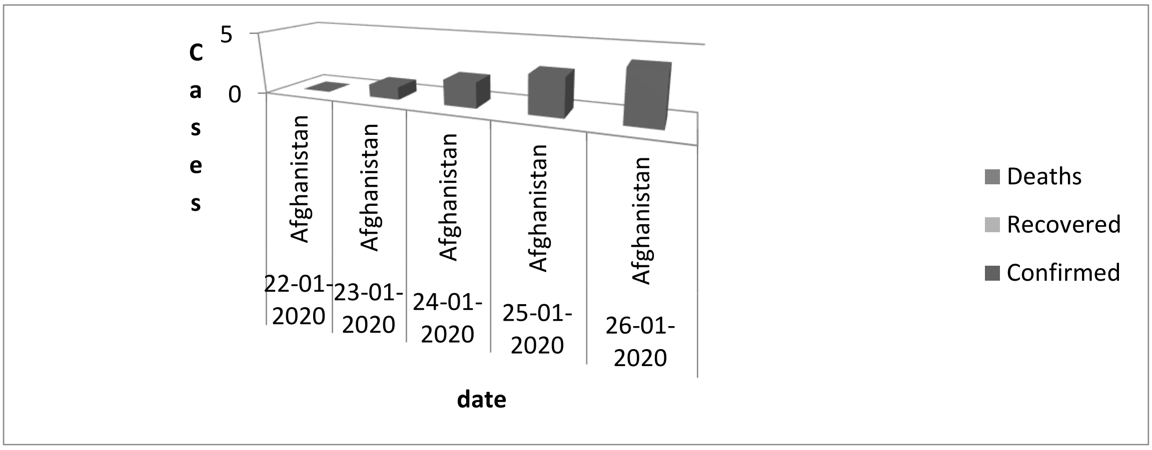

Fig 2: Graphically No of cases in Afghanistan

Fig 2 represents Covid 19 cases in Afghanistan in a graphical manner. In this graph Death cases, Recovered cases, confirmed cases are shown clearly.

Date	Country	Recovered	Deaths
2020-11-21	Zimbabwe	9172	8235
2020-11-22	Zimbabwe	9220	8250
2020-11-23	Zimbabwe	9308	8288
2020-11-24	Zimbabwe	9398	8297

Table 3: No of cases in Zimbabwe

Table 3 represents the no of cases in Zimbabwe. In this table provides recovered and Death cases due to Covid 19.

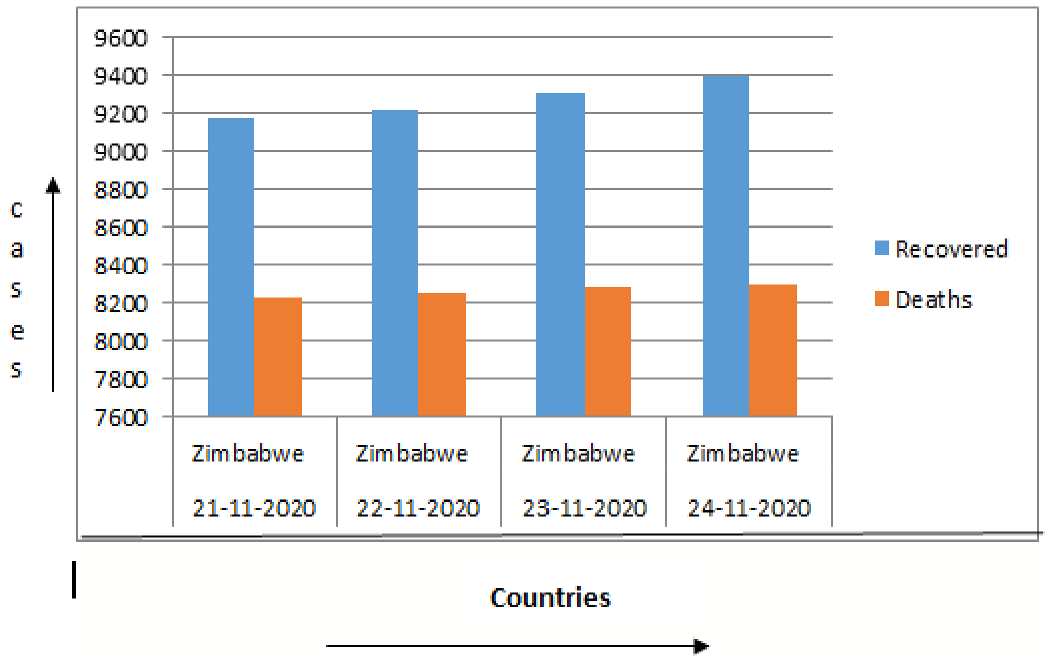

Fig 3: Covid 19 cases in Zimbabwe

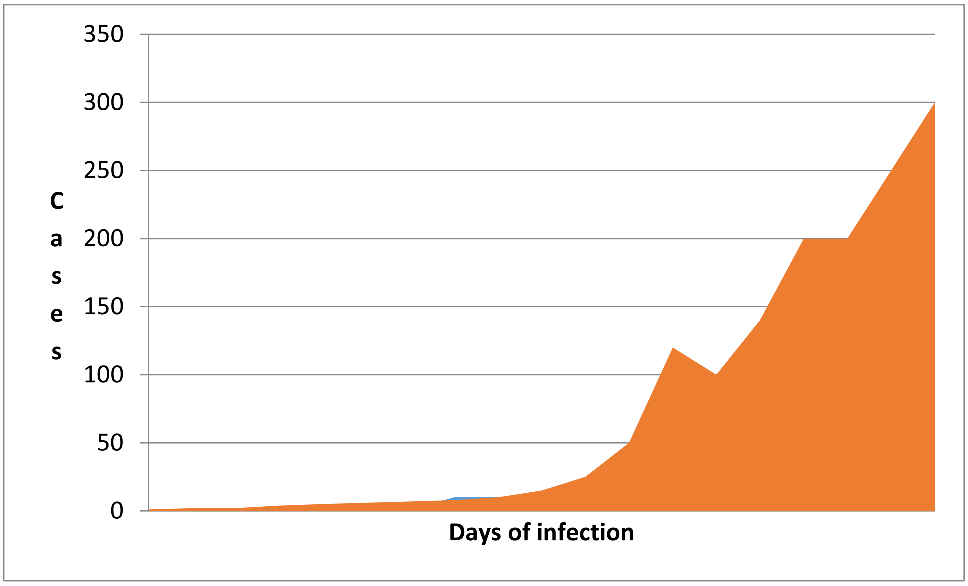

Fig 4: Cases Vs Day of infection

Fig 4 represents the Cases vs Day of infection

Country	Cases/Deaths by country wise for 28-Day	Total no of cases/Deaths cases
Japan	4,266,857/1,986	13,851,636/33,390
US	3,534,977/12,572	92,189,346/1,032,133
Germany	2,206,049/2,996	144858
Italy	1,992,793/3935	21286937/173062
France	1,918,397/2521	34237067/153577
Korea south	1,892,896/612	20383621/25236
Brazil	1,163,626/6,419	34011173/67939
Australia	1,161,876/1,919	9631110/12311

Table 4: Confirmed cases/Deaths cases

We have collected the data from this link. We have given some of the example cases for various countries in the above table. Remaining we have taken from the below datalink. We have implemented cases for different countries by using python in the below diagrams. It provides clear Data Visualization for various cases in different countries. The following diagram is retrieved from the below link.

https://data.humdata.org/dataset/novel-coronavirus-2019-ncov-cases

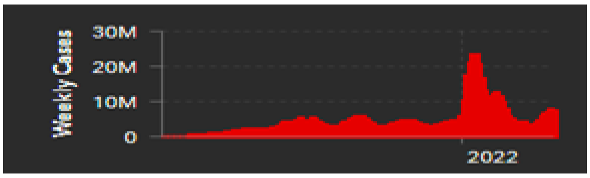

Fig 5: Weekly cases for different countries

https://data.humdata.org/dataset/novel-coronavirus-2019-ncov-cases

The datasets are taken from the below links.

time_series_covid19_confirmed_global.csv

time_series_covid19_deaths_global.csv

time_series_covid19_recovered_global.csv

time_series_covid19_confirmed_global_iso3_regions.csv

time_series_covid19_deaths_global_iso3_regions.csv

time_series_covid19_recovered_global_iso3_regions.csv

4.1 Choosing the model:

We apply logistic function, a specific case of sigmoid functions, considering that the original curve starts with slow growth remaining nearly flat for a time before increasing, eventually it could descend or maintain its growth in the way of an exponential curve[20].

The formula for the logistic function is:

$$Y=1/(1+e^{B1(X-B2)}) \text{ -------------------- } \textbf{Eq(5)}$$

4.2 Construction of the model:

Fig 5 represents the Day number Vs cases. It can be shown construction of the model according to number of cases [21].

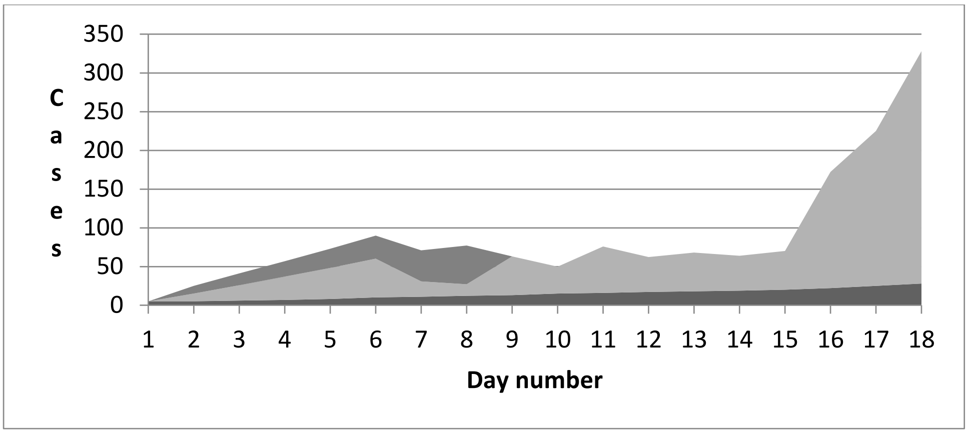

Fig 5: Day Number Vs Cases [21]

Fig 5 represents the Day number Vs cases. It can be shown construction of the model according to number of cases [21].

4.3 Data Normalization: Here, variables x and y are normalized assigning them a 0 to 1 range (depending on each case).So both can be interpreted in equal relevance.

4.4 Model Fitting:

The objective is to obtain new B optimal parameters, to adjust the model to our data. We use "curve_ fit" which uses non-linear least squares to fit the sigmoid function. Being "popt" our optimized parameters.

beta_1=9.833364

beta_2=0.777140

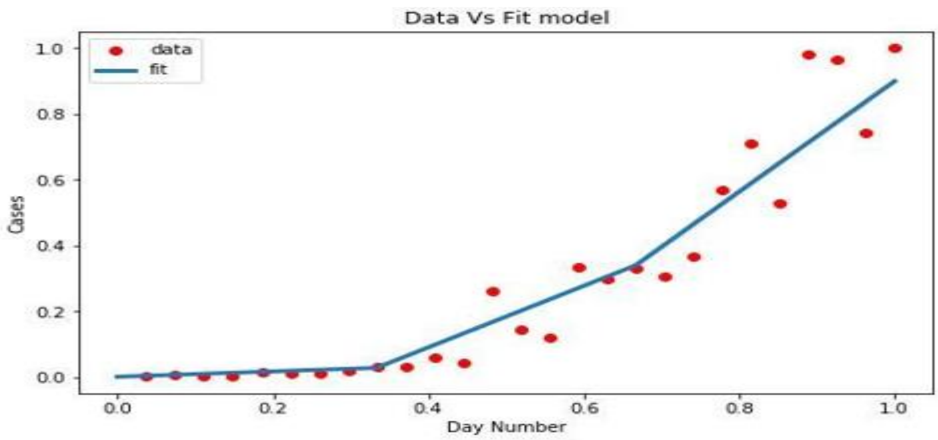

Fig 6: Data Vs Fit model

Fig 6 represents Data Vs Fit model. It has day number Vs Cases.

4.5 Model Evaluation Results: The model is ready to be evaluated. The data is split in at 80:20, for training and testing respectively [14,15]. The data is applied to the model obtaining the corresponding statistical means to evaluate the distance of the resulting data from the regression line[22].Results are implemented by using Python environment based on datasets[26,28].

Evaluation parameters are taken as Mean Square Error (MSE), Root Mean Square Error (RMSE), r2_score for identification of the best regression model .It predicts the best model about death cases. Future cases, Recovered cases[14].

$$RMSE = \sqrt{\frac{1}{k}\sum_{m=1}^{k}\left(a_m - \hat{a}_m\right)^2}$$ **-----Eq(6)**

Where, k = number of observations, aims the observed value, and am= the predicted value.

$$R2\_SCORE = 1 - \frac{\sum\left(t_i - \hat{t}_i\right)^2}{\left(t_i - \bar{t}_i\right)^2}$$ **-----Eq (7)**

i = the actual cumulative confirmed cases, b = predicted cumulative confirmed cases,

t_i =average of the actual cumulative confirmed cases.

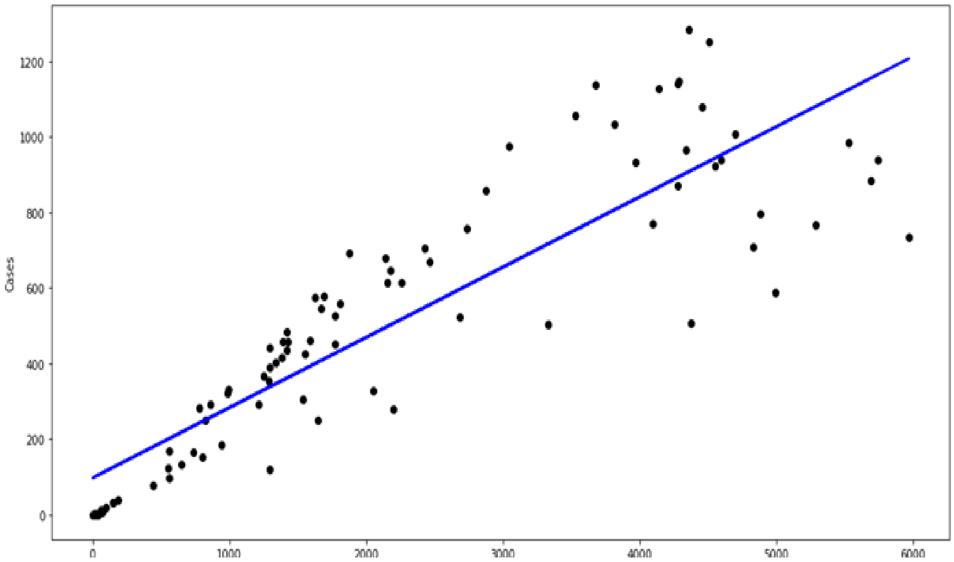

Fig 7 : Corona cases based on Linear regression [28]

Fig 7 shows the identification of Corona cases by using linear regression process

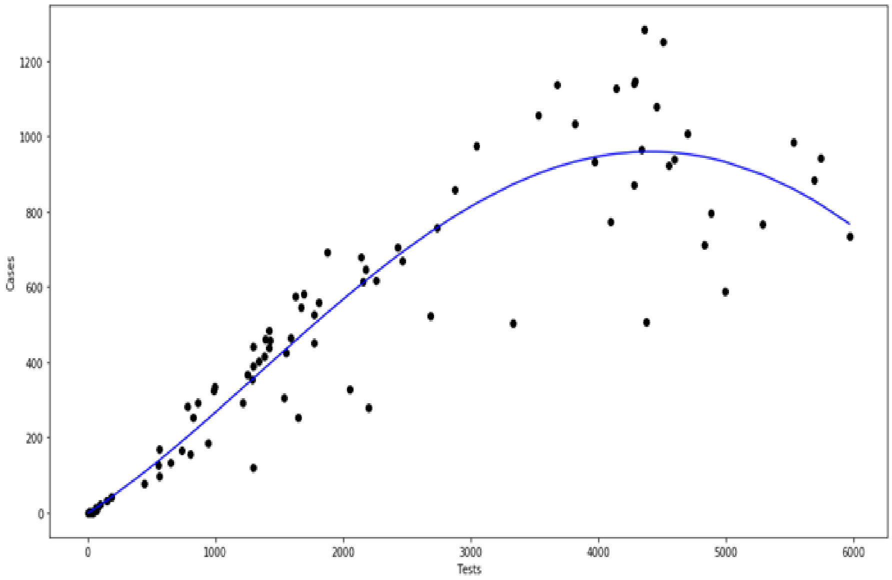

Fig 8: Cases Vs Tests based on Polynomial regression model[28]

Fig 8 shows the Cases Vs Tests based on Polynomial regression model.

Mean Absolute Error: It measures

$$MAE = \frac{1}{p}\sum_{q=1}^{p} |r_q - r|$$ **-----Eq(8)**

Where, p = number of errors, $|r_q\text{-}r|$ =the absolute errors. Mean S

$$MSE = \frac{1}{z}\sum_{s=1}^{z} (y_s - \hat{y}_s)^2$$ **----Eq(9)**

s =the observed values,

The investigation process shows forecasts on infected cases and concurring to results linear regression model performs better as compared to SVM.The below table shows the MSE, MAE, RMSE, R score values.

Model name	MSE	MAE	RMSE	R scroe
Linear regression	3320361601612823.5	57458125.4	57836358.0	-114.4
SVM	1995330053135026.2	38554555.9	43371335.2	-22

Table 4: Results for confirmed cases by using linear regression and SVM

5. CONCLUSION:

In this research paper, we have assessed the character of the scatter of the logistic model coefficients and its generalizations on the basis of the currently available COVID-19 data. The data of the epidemic development were used for the different countries. The investigation process shows forecasts on infected cases and concurring to results linear regression model performs better as compared to SVM. We have also focused on how to find the best fit regression model that can do future predictions.

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