

A Novel Algorithm for Data Centric Perspective Analysis on the Covid-19 Crisis

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Abstract—The sudden arise of novel corona virus in wuhan, china spread in a brief span of time, everywhere across the world. unfortunately, India is the second most affected country after united states with the case count of 33,971,607 and death count about 450,814. Sudden spread of covid -19 in India hit the indian economy strongly and leads to increased number of death when compared to others severe disease like severe Acute Respiratory Syndrome(SARS)and Spanish flu etc., Collection of data about recovered cases, confirmed cases and confirmed death helps government of india and health care workers to take prevention measures to control the pandemic situation. In this paper, a novel regression model has been introduced to predict with better accuracy the COVID cases. The goal of this research is to do a data centric perspective analysis on the various methods, such as decision trees, LSTMs, RNN and CNN algorithms to tackle the Corona virus outbreak. The collection includes information on positive samples, confirmed fatalities, and retrieved cases of the Covid-19 epidemic in India. With respect to the time period, three – fourth of the data is used as a training dataset and the remaining one – fourth as a test dataset. It not only analyses datasets effectively utilizing regression techniques such as LSTM, CNN, and DT, but it also calculates the r2 score at the end of the execution in Python notebook.

Index Terms— COVID-19, LSTM, Decision Tree, CNN, Machine learning.

I. INTRODUCTION

COVID-19 is an unexpected outbreak that began in Wuhan, China, in 19 th December and the news soon went around the globe. COVID-19 infected practically every country in a short period of time, resulting in over 4 million deaths. COVID-19 was declared a global pandemic by the WHO due to its rapid spread and high mortality toll. In a short period of time, the virus moved to India, a densely populated country, with the first case being discovered on January 30, 2020. Infection rates had decreased by September, and by January 2021, they had fallen below 15,000. In March 2021, a second wave of Covid 19 with a new Mutant variation swept over the country, wreaking havoc on the country. On April 30, India saw over 400,000 new cases and over 3,500 deaths in a single day.

Since then, a variety of quantitative approaches, including tracking the amount of affected, cured, and cases identified, have been used to quantify the epidemic's impact in India. SARS-CoV, a novel coronavirus that is quite similar to SARS, was discovered in 2002 and has spread to 37 countries. If compared to COVID-19, however, the numbers are far worse, over 219 people were infected worldwide. India became the second largest country in COVID 19 spread with 34 million cases, out of which 33 million were recovered, and 450K died as a result of the virus's lethal effects. The pandemic is linked to economic development, which obviously includes, financial, ecological, and social objectives. The long-term survivability hypothesis looks to be plausible, but one of the major barriers in the COVID-19 pandemic was anticipating the breakout epidemic and the emergency problems. It not only slows down the economy, but it also causes social problems, compromising the key pillar of sustainable growth. To mitigate the impact of COVID-19, some data scientists created a number of statistical solutions, one of which was to enforce a country-wide lockdown until the curve flattened or turn down. Despite the fact that these approaches have shown to be effective, they have wreaked havoc on the global social and economic system. As a result, it's vital to research the pandemic's consequences, and given everything, estimating the epidemic's pre-arrival is a must.

In order for political and healthcare authorities to make the right decisions in advance, it is critical to have an accurate forecast tool for the disease cases. Predicting future events depending on historical data utilising machine and statistical learning techniques is the goal of time-series forecasting. Spatial time-series forecasting, which predicts occurrences in the future for many locations or spaces, is a specific instance with fewer studies than other types of time-series forecasting [4].

Long short term memory (LSTM) [10], a recurrent neural network (RNN) that extracts the similarities between successive inputs by utilising three gates to govern the interaction between the past inputs, the current input, and the output, is one of the most extensively used methods. Those three gates are present in every LSTM cell, and the LSTM layer often has numerous LSTM cells.

Because of the CNN filters that group neighbour records with a window that may be selected and then a non-linear activation function is applied, it has recently attracted increasing interest in spatial time-series forecasting because of its ability to extract non-linear links between neighbour records. This is particularly beneficial in time-series in general, but especially in spatial time-series.

Because of their ease of visualisation, decision trees are amongst the most prominent machine learning methods. To put it another way, when we build a tree, we can tell right away which trait is the most important. As the nodes of the tree branch out, the resulting subsets become increasingly homogeneous, which is the goal of a decision tree. Different types of decision trees having varied depths can be developed for training the model given a dataset with multiple attributes.

To analyze the impact of the pandemic, we aimed to create a relevant machine learning model capable of making predictions when fed the WHO dataset, as well as perform basic analytic and visual operations to acquire a better understanding.

The paper is divided into five sections. Section 2 discusses the algorithms used in the literature for time series forecasting. Section 3 discusses the datasets and preprocessing methods. Section 4 discusses the results obtained and section 5 concludes the findings.

II. LITERATURE SURVEY

Earlier forecasting tools including artificial neural networks (ANN), long-short term memory (LSTM), and convolutional neural networks (CNN) delivered the expected results.

(Othman Istaiteh et al., 2020) proposed that taking precautions in preparation for the next seven days is beneficial. Five entries from the Covid-19 dataset are used here, out of 266 records from one day out of 161 days. Furthermore, by fine-tuning the four models with a validation set, the optimal configuration of the four models was established.

(Furqan et al., 2020) exhibits that ML models ability to forecast the future. In all prediction scenarios, exponential smoothing is the better model, followed by LR and LASSO, whereas SVM performs badly. They acquired all of the data from the github project (case covid 19 series). The LASSO linear regression technique uses the term "shrinkage," This is the process of extreme values in a sample data reducing towards a middle value. They also uses the same evaluating parameters mentioned in our studies named R^2 . They concluded by stating that generating an effective hyper - plane between the dataset's given values is extremely difficult. The study forecast can also be a great help for authorities to take timely action and their future work will be on real time forecasting.

(Yiqun et al., 2020) proposed the same CNN-LSTM regression model for traffic control by forecasting the following day's traffic flow. Due to non-linear and chaotic characteristics, long-term traffic flow forecast creates significant hurdles for decision-makers. In enhancing forecast accuracy, the wavelet based approach is utilized to split the raw traffic flow data into high and low pass data. The suggested CNN-LSTM model outperforms ARIMA, LSTM, CNN, MLP, and its counterpart without the wave from based decomposition technique when tested on real-life traffic flow data measured on the England main roads.

(Saud et al., 2021) used a Time-Series forecasting to perform data analysis using linear and polynomials regression which involves metrics like Accuracy, R^2 score and MAPE value.

III. DATASET AND PREPROCESSING

All of the data utilized in this research originates from the Indian government's daily actual records. The information is organized in a spreadsheet by verified cases, confirmed deaths, and confirmed recoveries. From January 1, 2021 to August 4, 2021, we have a total of 217 days of data. All of the data was segregated in a 70:30 ratio, with 70% of the data being labelled as train dataset and 30% being labelled as test dataset. The data is incorporated in the form of Csv. Files during processing, and the investigation of the Covid-19 crisis is continued in a python notebook.

TABLE I.

	S. No.	Region	Confirmed Cases	Active Cases	Cured/Discharged	Death
Date						
2020-12-03	4	India	74	71.0	3.0	0.0
2020-03-13	5	India	75	71.0	3.0	1.0
2020-03-14	6	India	84	72.0	10.0	2.0

The implementation processing of dataset python notebook follows the following steps:

❖ **Fitting a DT, LSTM, RNN and CNN algorithm to the Training set:**

The model will be adjusted to meet the data for training. For this, we'll use the sklearn. Tree package's Decision Tree Classifier class.

A classifier object is always with two major factors:

- **"Criterion='entropy':** The quality of a split is measured using the criterion, which is determined using the information gain supplied by entropy.
- **Random state=0"**

❖ **Predicting the test result:**

We're going to make a new prediction vector and it is as follow:

```
y_pred= classifier.predict(x_test)
```

❖ **Analysis of test result:**

We can deduce the result from the aforementioned analysis results. Some of them are correct and incorrect prediction the confusion matrix must be used.

❖ **Visualizing the test set result:**

The test result is always visualize in the form of graph.

IV. COMPARATIVE STUDY AND ANALYSIS OF ALGORITHM

The regression algorithm used for the prediction of covid-19 crisis in advance using current data are as follows:

- Decision tree
- Long-short term memory(LSTM)
- Convolutional Neural Network(CNN)

A. Decision Tree

A decision tree is an example of supervised learning, which is an artificial intelligence application in which a system can learn and develop on its own prior knowledge. It includes predict, learn, remember, decide, recognize, analysis of data.

A decision tree is a tree-like design that solves problems with qualitative answers such as "yes" as well as "no," "true" as well as "false," and "1" as well as "0."

There are two types of decision trees: classification and regression. To classify problems, classification provides a series of logic Boolean conditions. Ex: Classify the animals of forests using their certain features like color, height.

When the parameter is mathematical or ongoing in nature, the Regression tree method is applied. We used each of the regressor to fit a regression model to the input variables. The total of squared errors is used to make every split.

The Decision tree is easy to understand, interpret and visualize. It need a little effort to prepare data. It also involves non-linear parameters and can handle numerical data.

Overfitting is a problem with decision trees because it arises when the method catches distortion in the inputs. A minimal bias in a highly intricate decision tree makes it harder for the model to operate with new data. one more difficulties that decision tree faces is high variance this is because slight Overfitting is a problem with decision trees because it arises when the method catches distortion in the inputs. A minimal bias in a highly intricate decision tree makes it harder for the model to operate with new data. one more difficulties that decision tree faces is high variance this is because slight changes in data can make the data unsteady.

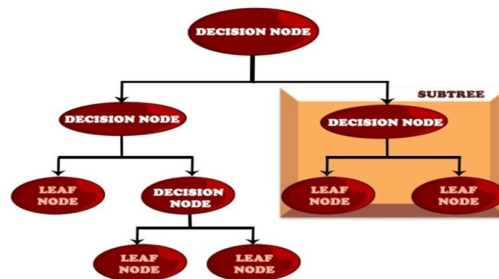


Figure 4.1.1 Decision Tree Flowchart

The three important term in decision tree are following:

After a dataset is divided and the leaf node bears the classification of choice, information gain is a measure of the decline in entropy.

Information Gain= Entropy(S)- [(Weighted Avg) *Entropy(each feature)]

$$\text{Entropy}(s) = -P(\text{yes})\log_2 P(\text{yes}) - P(\text{no})\log_2 P(\text{no}).$$

Where,

S stands for "total number of samples".

P of (yes) = the likelihood of a yes answer.

P of (no) = the likelihood of a negative outcome.

The entropy of a statistic is a measure of its variability or unreliability.

Comparison, Analysis and Prediction for india using Decision tree regressor:

By pressing linked to the Host runtime, you first connected to the server. The relevant dataset of confirmed cases is then uploaded.

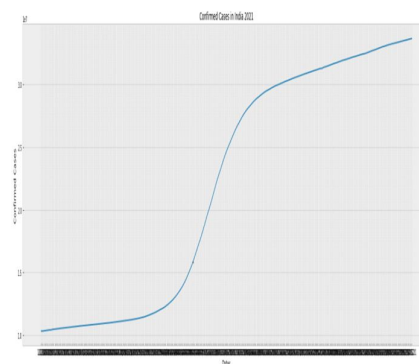


Figure 4.1.2 Decision Tree: confirmed cases in 2021

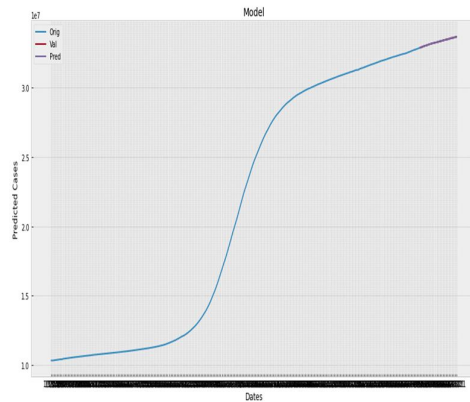


Figure 4.1.3 Decision tree: Predicted cases in India in 2021

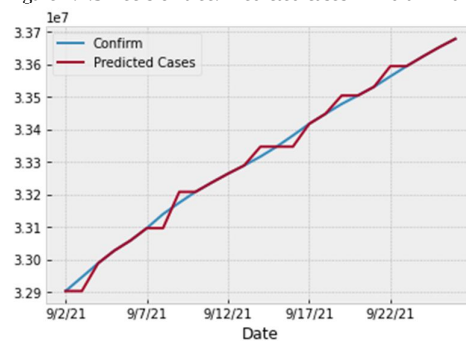


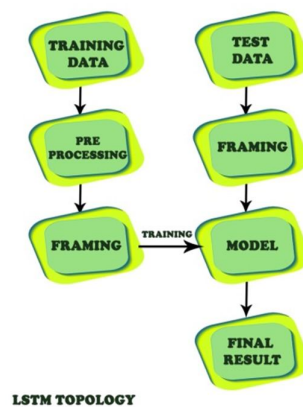
Figure 4.1.4 Decision tree: Confirmed cases vs predicted cases in India in 2021

The data selected for covid-19 analysis in India start from January 1, 2021 to August 4, 2021. All the comparison observed are based on the given test data. Hence, discussed the graph

1. The graph for the confirmed cases in India in 2021 is initially low and then started rise slightly and back to the low position
2. The projected cases in India in 2021 graph seems similar to the confirmed cases graph.
3. The third graph shows that predicted cases and confirmed cases are nearly same at differ at some point.

B. Long-Short Term Memory (LSTM)

A multilayer perceptron with long short-term memory is a special sort of recurrent neural network which process data using three models namely sequence-vector model, vector-sequence model, sequence – sequence model. It can handle not only individual data points, but also complete data streams. LSTM is for mitigate the vanishing and exploding the gradient problem



LSTM TOPOLOGY

Figure 4.2.1 LSTM Topology

LSTM parameters that always control flow of information within in the nodes and LSTM nodes are simply more complicated when compared to other recurrent models. In simple, easy way of understanding LSTM is that contain bunch of data in which is used to solve the future prediction in recurrent way.

Comparison, Analysis and Prediction for India using LSTM regressor:

First connected to the server by pressing connected to the Host runtime. Followed by upload the required dataset of confirmed cases.

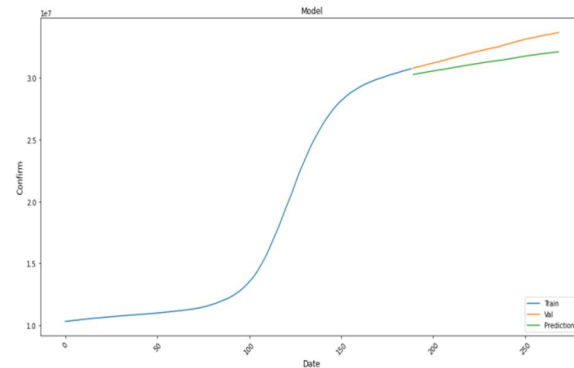


Figure 4.2.2 LSTM: Confirmed cases in india in 2021

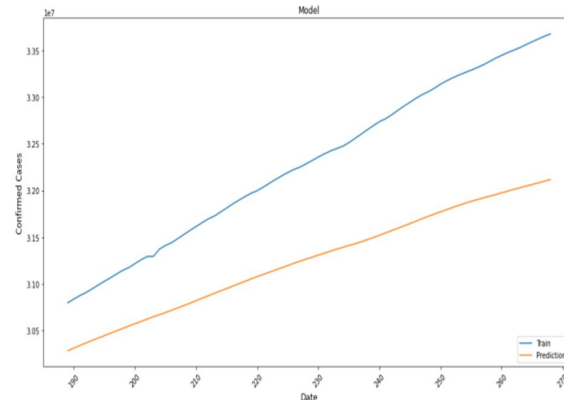


Figure 4.2.3 In India in 2021, LSTM: confirmed vs. anticipated instances

India's covid-19 analysis uses data from January 1, 2021 to August 4, 2021. All of the observed comparisons are based on the test data that has been provided. As a result, consider the following graph:

1. In the first plotted graph, the test dataset is tested, and the graph seems low at first, then progressively climbs before returning to a flat state. The validation set of data is then compared to the confirmed cases, with the predicted line in the graph appearing below the validation line.
2. The line of confirmed cases is above the line of anticipated cases in the second graph, indicating that forecast cases will be smaller than confirmed instances.

C. Convolutional Neural Network

The Convolutional Neural Network is also known as comp net is an artificial network which is more commonly used for image analysis and it can also be used for data analysis and classification of problem.

The main term in CNN is that pattern detection which make it more convenient for analysis of image. This kind of artificial network differentiates itself from MLP or multilayer perceptron.

The basis of CNN is that convolutional layers well it also comprises of non-convolutional layers. Convolutional layers receives input and transform output as input to the next layer. Convolutional neural network always uses pattern and filters for the process of image analysis.

CNNs are regularized forms of multilayer perception, because of their "full connectivity", which is followed by image map and subsampling from the input entered into the hidden layer which is actually a output of convolutions.

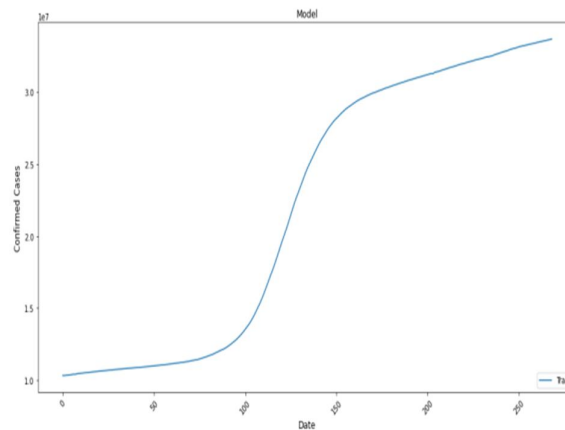


Figure 4.3.1 CNN: Confirmed cases in India in 2021

The above graph of CNN using confirmed cases states that the curve appear inclined position initially then arises up to some extent again it went back to the inclined position.

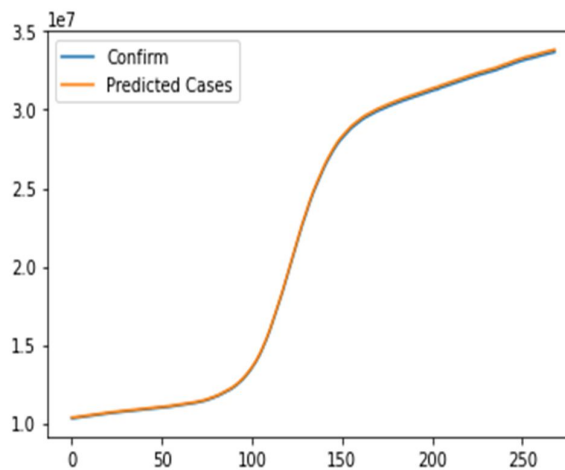


Figure 4.3.2 CNN: Confirmed cases vs predicted cases in India in 2021

The above is the graph for both confirmed cases and predicted cases in which both curves appear on the same position with slight deviation.

D. Recurrent Neural Network

Recurrent Neural Networks (RNNs; Robinson & Fallside, 1987; Werbos, 1988; Williams, 1989) are a type of connectionist model that has internal state or short-term memory as a result of recurrent feed-back connections, making them suitable for solving sequential problems like speech classification, prediction, and generation. Due to diminishing gradients, simple RNNs trained with stochastic gradient-descent have trouble learning long-term dependencies contained in the input sequences (i.e. spanning more than 10 time-steps) (Hochreiter, 1991; Hochreiter et al.,

E. Machine Learning Algorithms to Give the Accuracy of Predictions

The different machine learning algorithms such as Logistic Regression (2001). Long ShortTerm Memory (LSTM) networks (Hochreiter & Schmidhuber, 1997) use a specialised neuron structure, or cell, that maintains constant backward flow in the error signal; second-order optimization methods (Martens & Sutskever, 2011) preserve the gradient by estimating its curvature; and informed random initialization (Sutskever et al., 2013) allows for training the networks with momentum and stochastic gradient descent only.

K-NN Classifier, Decision Tree Classifier, Random Forest Classifier, Gradient Boosting Classifier and Linear SVC are used for training and testing the dataset. The accuracy of each algorithms is calculated to give the

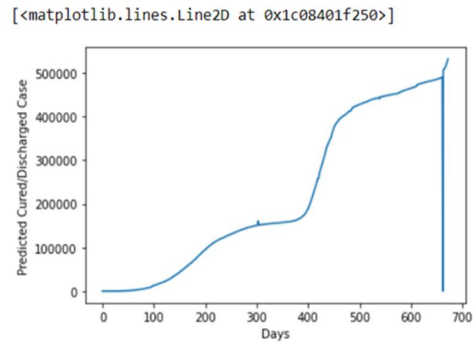


Fig. 4.4.1 Prediction of the cured/discharged cases using RNN

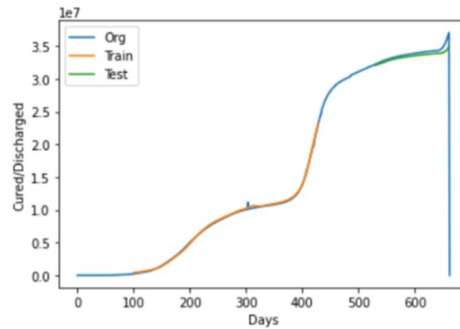


Fig. 4.4.2: Confirmed representation of Cured/discharge cases

accuracy of prediction of COVID-19 cases. Fig. 4.5.1 gives the accuracy of each algorithm and Table 2 gives the numerical value of accuracy obtained.

The various classifiers are discussed below:

Logistic Regression: Logistic regression is a widely used method for predicting a categorical answer in a variety of situations. Generalized Linear models (GLMs) are a subset of Generalized Linear models which predicts the likelihood of different outcomes.

K-NN Classifier: This technique is an instance-based learning method that classifies items based on the k training examples that are the closest to each other in the resource space.

Decision Tree Classifier: Regression and classification techniques are used in decision tree classifier. When solving a problem, a decision tree is used whereby every leaf node correlates to a class label while attributes is expressed on the internal node of the tree, the problem is solved using a tree representation.

Random Forest Classifier: The RF method is based on the building of many decision trees, which are then combined to produce a decision that is more accurate and consistent.

Gradient Boosting Classifier: Gradient-boosted trees (GBTs) are a common regression and classification method that employs ensembles of decision trees to do classification and regression.

Linear SVC: Using a support vector machine, a hyperplane or series of hyperplanes is constructed in a high-dimensional space (or an infinite-dimensional space), which can then be utilised for regression, classification, and similar tasks.

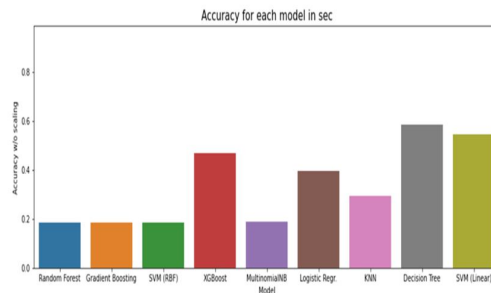


Fig. 4.5.1 Comparison of the accuracy of each model

TABLE II

Algorithm used	Accuracy obtained
Random Forest	18.51
Gradient Boosting	18.51
Logistic Regression	29.37
KNN	58.51
Decision Tree	18.98
SVM (Linear)	54.51

From the Table.II it can be seen that KNN algorithm gives the highest accuracy for prediction of COVID-19.

F. Partial Pseudo Linear Regression

A new novel regression algorithm has been introduced in this paper to obtain better accurate prediction of COVID cases.

In this model, Partial Pseudo Linear Regression (PPLR) model which is a combination of Partial Least Squares (PLS) and Pseudo Linear Regression (PLR) is used. PLS is a broad category of approaches for using latent variables to describe relationships between sets of observable variables. Regression and classification tasks, as well as dimension reduction techniques and modelling tools, are all included. The observed data is generated by a system or process that is driven by a small number of latent (not directly observable or measured) variables, which is the basic assumption of all PLS approaches. Herman Wold and associates developed PLS-based projections of observable data to its latent structure.

Specifically, in partial least squares (PLR), parametrization has a significant impact on the convergence conditions of the identification method, and the basis poles can be utilised as tuning parameters to loosen the convergence constraints of classical PLR schemes.

The analysis of the bias distribution is carried out using the recently created notion of equivalent prediction error [17], which corresponds to the signal whose variance is effectively minimised in the PLR scheme and is used to calculate the bias distribution.

G. Discussion on Regression Algorithms

Various regression algorithms like Single Linear Regression, Multiple Linear Regression, Lasso Regression and Hist Gradient Boosting Regression are used for getting the accuracy of prediction of COVID-19. Table 3 gives the accuracy values of the regression algorithms used.

Single Linear Regression: Single Linear Regression comes under Linear Regression techniques. Utilizing a single feature, the response is predicted in this technique. An important assumption is that the variable are related linearly.

Multiple Linear Regression: The most often used statistical strategy for linking a group of two or more variables is the multiple linear regression model.

GLM Regression: Known as generalised linear models (GLMs), they are a type of regression model that allows us to generalise the linear regression approach to accommodate many different types of response variables [1,2]. These

response variables include count, binary, proportion, and positive valued continuous distributions, among others. Because of its versatility in addressing a wide range of statistical problems and the availability of software to support the models, it is widely regarded as a powerful statistical tool and is widely utilised in practise. As a matter of fact, the generalised linear model (GLM) has been dubbed "the most significant innovation in regression analysis in the last twenty years" [2].

LASSO Regression: As part of the linear regression family of models, LASSO employs shrinkage as a method of fitting the data. The term "shrinkage" refers to the process of bringing extreme values of a data sample closer to the centre. As a result of the shrinking process, LASSO becomes better and more stable, as well as reducing error.

Poisson Regression: The Poisson regression model is, in essence, a regression model that meets all of the classical assumptions with the exception of a single one. The only difference is that the dependent variable is assumed to have a Poisson distribution. When a random variable has a value of 0, 1, 2, 3,..., n, this is a highly typical distribution for that variable. Considering a Poisson distribution, there is a defined likelihood function that can be used to create the maximum likelihood estimator, which is a good starting point (MLE). This model can be used to acquire estimates of unknown regression parameters, which are then used in other models.

Bayesian Regression: Bayesian linear regression provides a handy tool for dealing with insufficient data or data that is not evenly distributed. There is the option of setting up a prior on the coefficients as well as the noise, so that the priors can take precedence in the absence of data. More crucially, you can ask Bayesian linear regression

which portions of it it is confident in, and which parts it is doubtful about, in terms of how well it fits the data (perhaps based entirely on the priors).

Hist Gradient Boosting Regressor: Gradient boosting has a big drawback in that it takes a long time to train the model. This is especially problematic when working with huge datasets including tens of thousands of examples (rows).

By discretizing (binning) the continuous input variables to a few hundred unique values, training the trees that are introduced to the ensemble can be greatly expedited. Histogram-based gradient boosting ensembles are gradient boosting ensembles that use this method and adjust the training algorithm to the input variables under this transform.

LARS Regression: Forward Selection (also known as "forward stepwise regression," as described in Weisberg [(1980), Section 8.5]) is a classic model-selection method that is related to Least Angle Regression (LARS): given a collection of possible predictors, we select the one with the largest absolute correlation with the response

Ridge Regression: Hoerl and Kennard (1970) proposed the approach of Ridge Regression as an alternative to least squares estimation of the coefficients of a linear model, and it has since gained popularity. They argued that their method had advantages in situations when the explanatory variables were non-orthogonal in nature.

SVR Regression: Support Vector Regression (SVR) is a machine learning technique that, rather than attempting to minimise the observed training error, aims to decrease the generalisation error bound in order to achieve generalized performance. The concept of SVR is based on the computation of a linear regression function in a high-dimensional feature space in which the input data are mapped using a nonlinear function, while the input data are mapped using a linear function. Different domains have made use of SVR, such as time series and financial (noisy) prediction, approximation of difficult engineering studies, convex quadratic programming and the selection of loss functions, among others.

TABLE III.

Regression Algorithm used	Accuracy obtained
Single Linear Regression	90.92
Multiple Linear Regression	91.00
Lasso Regression	90.98
Hist Gradient Boosting Regression	86.06

From Table 3. it can be seen that the accuracy given by multiple linear regression is the highest. When comparing the accuracies of machine learning algorithms and regression algorithms it can be seen that regression algorithms gives better accuracy for predicting COVID-19.

H. Evaluation Parameter

In this study, we calculate the performance of LSTM, CNN & Decision tree using R-squared score

The statistic displays the variance percentage of the dependent variable, which is used to determine the independent variable. On a handy 0–100 percent scale, it assesses the strength of the association between the dependent variable and regression model. The R2 score, also known as the co-efficient of determination. It always has a score between 0 and 100 percent. The response variable with a 0% score has no variability around its mean. The trained strong R^2 score demonstrates its effectiveness. The latter compensates for the number of variables in a forecasting model and can be obtained as: If the new updated features are useful to the forecasting model, the rise in additional features can lead to an increase in R^2 adjusted. The R^2 adjusted is defined as follows:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

Where

r is a The correlation coefficient

n is a number in the given dataset

x is a first variable in the context

y is a second variable

The following table. 4 shows R^2 score for the regression models using the dataset collected in India in 2021:

TABLE IV.

MODELS	R2 SCORE
Decision tree	0.9897
LSTM	0.5970
CNN	0.98979
Linear Regression	0.9829
Lasso Regression	0.89277
Poisson Regression	0.1006
GLM	0.3893
HGBT	0.853
PPLR	0.9927
Bayesian	0.8927
LARS	0.8027
Ridge	0.9027
SVR	0.104

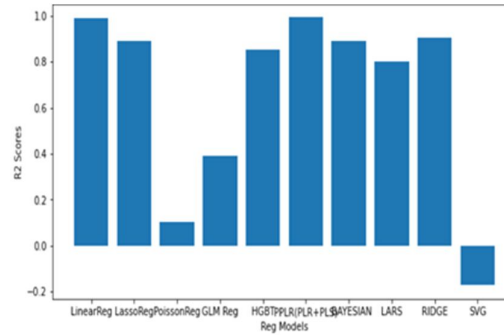


Fig. 4.8.1: Comparison of the R2 score of the various regression models

V. CONCLUSION

The lack of awareness and precariousness in the novel corona virus pandemic has a potential to affect entire world economic status. Some academics and government units around the world are concerned that the epidemic would affect a significant section of the global population. A data-centric, model-based prediction technique is created in this study for evaluating the global likelihood of COVID-19 outbreaks. The system uses Decision tree, LSTM, and CNN to analyze a dataset containing day-by-day actual data from January 1, 2021 to August 4, 2021. Finally, the R2 evaluation parameter is utilized to determine which of the three algorithms is the best between the dataset's given values. On the whole, we surmise that model projections are accurate, which could be useful in predicting future events. The study's forecasts can thus be extremely useful in assisting authorities in taking appropriate actions and making decisions in order to contain the COVID-19 ruin. This research will be improved over time; next, we want to look into a prediction method based on the new dataset and use the most relevant forecasting methodologies. Real-time live forecasting will be a major emphasis of our research plan.

REFERENCES

- [1] Othman Istaiteh, Tala Owais, Nailah Al-Madi, Saleh Abu-Soud "Machine Learning Approaches for COVID-19 Forecasting" 2020 International Conference on Intelligent Data Science Technologies and Applications (IDSTA).
- [2] Furqan Rustam, Aijaz Ahmad Reshi (Member, IEEE), Arif Mehmood, Saleem Ullah, Byung - Won, Waqar Aslam (Member, IEEE) and Gyu Sang Choi "COVID-19 Future Forecasting Using Supervised Machine Learning Models" on IEEE Access Volume 8, 2020.
- [3] Yiqun Li, Songjian Chai, Zhengwei Ma (Member of IEEE) "A Hybrid Deep Learning Framework for Long-Term Traffic Flow Prediction" On IEEE access Volume 9, 2021.
- [4] Saud Shaikh, Jaini Gala, Aishita Jain, Sunny Advani, Sagar Jaidhara, Dr. Mani Raja Edinburg on IEEE access in the name of "Analysis and prediction of COVID-19 using Regression Models and Time Series Forecasting" 11th International Conference on Cloud Computing, Data Science & Engineering (Confluence) 2021.
- [5] Mingyang Pan, Hainan Zhou, Jiayi Cao, Yisai Liu, Jiangling Hao, Shaoxi Li and Chi-Hua Chen (SENIOR MEMBER OF IEEE) "Water Level Prediction Model Based on GRU and CNN" on IEEE Access volume 9, 2020.

- [6] Han Wu, Wenjie Ruan (Member of IEEE), Jiangtao Wang , Dingchang Zheng (Member of IEEE), Bei Liu, Yayuan Geng, Xiangfei Chai, Jian Chen, Kunwei Li, Shaolin Li and Sumi Helal(Fellow of IEEE) “Interpretable Machine Learning for COVID-19: An Empirical Study on Severity Prediction Task” on IEEE , 2020.
- [7] Dr.D.Haritha,N.Swaroop,M.Mounika ‘‘Prediction of COVID-19 Cases using CNN with X-rays’’ 2020 IEEE
- [8] Gaobo Liang,Huichao Hong,Weifang Xie and Lixin Zheng ‘‘Combining Convolutional Neural Network With Recursive Neural Network for the Blood Cell Image Classification’’ 2018 on IEEE
- [9] Hassam Tahir, Annas Iftikhar and Mustehsan Mumraiz‘‘Forecasting COVID-19 via Registration Slips of Patients using ResNet-101 and Performance, Analysis and Comparison of Prediction for COVID-19 using Faster R-CNN, Mask R-CNN and ResNet-50’’ 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT).
- [10] Vishan Kumar Gupta,Avdhesh Gupta,Dinesh Kumar and Anjali Sardhana ‘‘Prediction of COVID-19 confirmed, Death, and Cured Cases in India Using Random Forest Model’’ on IEEE volume 4,2021.
- [11] Rajani kumara,Sandeep Kumar, Ramesh Chandra Poonia, Vijander Singh, Linesh Raja, Vaibhav Bhatnagar and Pankaj Agarwal ‘‘Analysis and prediction of Spread, Recovery, and Death Caused by COVID-19 in India’’ on IEEE volume 4,2021.
- [12] Felix Gers. Long Short-Term Memory in Recurrent Neural Networks. PhD thesis, École Polytechnique Fédérale de Lausanne, 2001.
- [13] A. Graves and J. Schmidhuber. Framewise phoneme classification with bidirectional lstm and other neural network architectures. *Neural Networks*, 18(5-6):602–610, 2005.
- [14] Graves and J. Schmidhuber. Framewise phoneme classification with bidirectional LSTM networks. In *Proc. Int. Joint Conf. on Neural Networks IJCNN 2005*, 2005.
- [15] Alex Graves. Supervised sequence labelling with recurrent neural networks. PhD thesis, Technical University Munich, 2008.
- [16] Alex Graves. Generating sequences with recurrent neural networks. *CoRR*, abs/1308.0850, 2013.
- [17] Klaus Greff, Rupesh Kumar Srivastava, Jan Koutník, Bas R. Steunebrink, and Jürgen Schmidhuber. LSTM: A Search Space Odyssey. *CoRR*, abs/1503.04069, 2015.
- [18] S. Grossberg. Recurrent neural networks. *Scholarpedia*, 8(2):1888, 2013. revision #138057.
- [19] Stephen Grossberg. Nonlinear neural networks: Principles, mechanisms, and architectures. *Neural Networks*, 1:17–61, 1988.
- [20] Eldad Haber and Lars Ruthotto. Stable architectures for deep neural networks. *Inverse Problems*, 34(1):014004, 2017.
- [21] Sepp Hochreiter and Jürgen Schmidhuber. Long Short-Term memory. *Neural computation*, 9(8):1735–1780, 1997.
- [22] Sepp Hochreiter, Bengio Yoshua, Frasconi Paolo, and Jürgen Schmidhuber. Gradient flow in recurrent nets: the difficulty of learning long-term dependencies. In Kremer and Kolen, editors, *A Field Guide to Dynamical Recurrent Neural Networks*. IEEE Press, 2001.
- [23] J. J. Hopfield. Neurons with graded response have collective computational properties like those of two-state neurons. *Proceedings of the National Academy of Sciences*, 81:3088–3092, 1984.
- [24] Varuna Jayasiri. Vanilla LSTM with numpy. http://blog.varunajayasiri.com/numpy_lstm.html, 2017.
- [25] M. I. Jordan. Serial order: A parallel distributed processing approach. Technical Report ICS Report 8604, Institute for Cognitive Science, University of California, San Diego, 1986.
- [26] Anjuli Kannan, Karol Kurach, Sujith Ravi, Tobias Kaufmann, Andrew Tomkins, Balint Miklos, Greg Corrado, László Lukács, Marina Ganea, Peter Young, and Vivek Ramavajjala. Smart reply: Automated response suggestion for email. *CoRR*, abs/1606.04870, 2016.
- [27] Andrej Karpathy. The unreasonable effectiveness of recurrent neural networks. <http://karpathy.github.io/2015/05/21/rnneffectiveness>, 2015.
- [28] Yuliya Kyrychko and Stephen Hogan. On the use of delay equations in engineering applications. 16:943–960, Jul 2010. 41 Journal Pre-proof Journal Pre-proof
- [29] Omer Levy, Kenton Lee, Nicholas FitzGerald, and Luke Zettlemoyer. Long short-term memory as a dynamically computed element-wise weighted sum. *CoRR*, abs/1805.03716, May 2018.
- [30] Qianli Liao and Tomaso A. Poggio. Bridging the gaps between residual learning, recurrent neural networks and visual cortex. *CoRR*, abs/1604.03640, Apr 2016.
- [31] Henry W. Lin and Max Tegmark. Criticality in formal languages and statistical physics. *Entropy*, 19(7):299, Aug 2017.
- [32] Zachary Chase Lipton. A critical review of recurrent neural networks for sequence learning. *CoRR*, abs/1506.00019, 2015.
- [33] Yiping Lu, Aoxiao Zhong, Quanzheng Li, and Bin Dong. Beyond finite layer neural networks: Bridging deep architectures and numerical differential equations. In Jennifer G. Dy and Andreas Krause, editors, *ICML*, volume 80 of *Proceedings of Machine Learning Research*, pages 3282–3291. PMLR, Nov 2018.
- [34] Arun Mallya. Introduction to RNNs. http://slazebni.cs.illinois.edu/spring17/lec02_rnn.pdf, 2017.
- [35] Arun Mallya. LSTM Forward and Backward Pass. <http://arunmallya.github.io/writeups/nn/lstm/index.html>, 2017.
- [36] Arun Mallya. Some RNN Variants. http://slazebni.cs.illinois.edu/spring17/lec03_rnn.pdf, 2017.
- [37] J. H. McClellan, T. W. Parks, and L. R. Rabiner. A computer program for designing optimum fir linear phase digital filters. *IEEE Transactions on Audio Electroacoustics*, 21(6):506–526, 1973.

- [38] N. Metropolis, A. Rosenbluth, M. Rosenbluth, A. Teller, and E. Teller. Equation of state calculations by fast computing machines. *J. Chem. Phys.*, 21:1087, 1953.
- [39] M.L. Minsky and S.A. Papert. *Perceptrons*. MIT Press, Cambridge MA, second edition, 1990.
- [40] Christopher Olah. Understanding LSTM Networks. <http://colah.github.io/posts/2015-08-Understanding-LSTMs>, 2015.
- [41] Oleksii Ostroverkhyyi. Neural network processing of multidimensional signals. PhD thesis, Kharkiv National University of Radioelectronics, 2010.
- [42] Hamid Palangi, Li Deng, Yelong Shen, Jianfeng Gao, Xiaodong He, Jianshu Chen, Xinying Song, and Rabab K. Ward. Deep sentence embedding using the long short term memory network: Analysis and application to information retrieval. *CoRR*, abs/1502.06922, 2015.
- [43] Razvan Pascanu. On Recurrent and Deep Neural Networks. PhD thesis, Université de Montréal, 2014.
- [44] Razvan Pascanu, Tomas Mikolov, and Yoshua Bengio. On the difficulty of training recurrent neural networks. In *International Conference on Machine Learning*, pages 1310–1318, 2013.
- [45] Barak A. Pearlmutter. Learning state space trajectories in recurrent neural networks. *Neural Computation*, 1(2):263–269, 1989.
- [46] Barak A. Pearlmutter. Dynamic recurrent neural networks. Technical Report CMU-CS-90-196, Computer Science Department, Carnegie Mellon University, Pittsburgh, PA, 1990.
- [47] F. J. Pineda. Generalization of backpropagation to recurrent neural networks. *Physical Review Letters*, 59(19):2229–2232, 1987.
- [48] Fernando L. Pineda. Generalization of backpropagation to recurrent and higher order neural networks. In Dana Z. Anderson, editor, *Neural Information Processing Systems*, pages 602–611. New York: American Institute of Physics, 1987.
- [49] L. R. Rabiner. Techniques for designing finite-duration impulse-response digital filters. *IEEE Transactions on Communications Technologies*, 19(2):188–195, 1971.
- [50] Paul Renvoisé. Machine learning spotlight i: Investigating recurrent neural networks. <https://recast.ai/blog/ml-spotlightrnn/>, 2017.