COMPARATIVE ANALYSIS OF COVID-19 CASES USING DEEP LEARNING ALGORITHMS

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ABSTRACT

The novel human coronavirus disease 2019 (COVID- 19) was first reported in Wuhan, China, in 2019, and subsequently spread globally to become the fifth documented pandemic since the 1918 flu pandemic. On the 11th of March, 2020, COVID-19 was declared a pandemic by the WHO. COVID-19 rapidly transformed from being a severe problem seemingly confined to China, to a global health emergency almost overnight. By September 2021, almost two years after COVID-19 was first identified, there had been more than 200 million confirmed cases and over 4.6 million lives lost to the disease. During that period various researchers conducted research and developed prediction models to predict COVID-19 cases all over the world using deep learning algorithms. The objective of this study is to perform a comparative analysis on the prediction models to predict the growth of COVID-19 The prediction accuracies are to be compared and, accordingly, the most suitable model is selected.

Keywords - COVID-19, deep learning, machine learning, WHO

[1] INTRODUCTION

Due to the increased enormity of the number of COVID-19 cases, the role of Artificial Intelligence (AI) is imperative in the current scenario. AI would be a powerful tool to fight against this pandemic outbreak by predicting the number of cases in advance. Deep learning-based time series techniques are considered to predict world-wide COVID-19 cases in advance for short-term and medium-term dependencies with adaptive learning.[1]. The rampant spread of the COVID-19 pandemic has resulted in huge economic, human life loss and disruption of normal public life across the globe According to the World Health Organization (WHO), over 200 million people have been infected by the SARS-CoV-2 virus worldwide. Recently, machine learning models have been extensively used for forecasting

and can be especially useful in terms of pandemic planning [2]. In order to control the situation, it is essential to have a plan in place, which depends on the prediction of new cases due to COVID-19. This would help hospitals and administrations to take necessary measures in advance. In the context of an emerging infectious disease outbreak, predicting the trend of the epidemic is of paramount Importance to plan effective control strategies and determine how said strategies impact the course of the epidemic. [6].

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The spread of novel corona virus across the globe has a significant impact on various stake holders and posting a major challenge to the research community. Government has taken several measures for maintaining social distance and containment of disease, but still it is not a sufficient for the developing countries like India where the level of understanding the issue is deprived and hence it is a major challenge to the Health Care professionals. Therefore, it is mandatory that a prediction of the number of possible cases enables the preparedness of the Government and the Hospitals in resolving the issues and to take measures in controlling the spread of the disease Series [10]

The pandemic of novel coronavirus disease 2019 (Covid- 19) has left the world to a standstill by creating a calamitous situation. To mitigate this devastating effect the inception of artificial intelligence into medical health care is mandatory [16]

Detection and prediction of the novel Coronavirus present new challenges for the medical research community due to its widespread across the globe. Methods driven by Artificial Intelligence can help predict specific parameters, hazards, and outcomes of such a pandemic. Recently, deep learning-based approaches have proven a novel opportunity to determine various difficulties in prediction. [17]

Machine Learning (ML) is an actually powerful tool in the fight against the COVID-19. It can be used to manage huge data and effectively predict the spread of the disease. It helps in diagnosis and predicts COVID-19. ML Techniques are useful in tracing COVID cases, predicting, creating dashboards, diagnose and give proper medications, generating alerts to support social distance and also for other potential control mechanisms of the spread of virus.[21]

Deep learning technology is a practical, valuable and suitable technique that can be deemed reliable for adequate diagnosis of the COVID-19 virus. Deep learning (DL) is contributing significantly in combating against COVID-19 Hence, DL based methods have been widely used for the detection of COVID-19.

[2] RELATED WORK

Jayanthi Devaraj et al.[1] has analysed and predicted Country-specific and city-specific cases of COVID-19 for India and Chennai, respectively. In this study cumulative confirmed, death and recovered global cases are modeled with Auto-Regressive Integrated Moving Average (ARIMA), Long Short-Term Memory (LSTM), Stacked Long Short-Term Memory(SLSTM) and Prophet approaches . Subsequently, for long-term forecasting of COVID-19 cases, a multivariate LSTM model is employed.

Lu Xu et al.[2] developed, three deep learning models, including CNN, LSTM and the CNN-LSTM to predict the number of COVID- 19 cases for Brazil, India and Russia. This study has also compared the performance of proposed models with the previously developed deep learning models and noticed significant improvements in prediction performance. Among the models developed in this work, the LSTM model had the highest performance when forecasting and shown an improvement in the forecasting accuracy compared with some existing models.

Ganesh Yenurkar et al.[3] has analysed the occurrence of COVID-19 dissemination beyond the world and an artificial-intelligence (AI) based deep learning algorithm is

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suggested to detect positive cases of COVID19 patients, mortality rate and recovery rate using real-world datasets. Parul Arora et al.[4] have used Deep Learning-based models for predicting the number of novel coronavirus (COVID-19) positive reported cases for 32 states and union territories of India. RecurrentNeural Network (RNN) based long short term memory (LSTM) variants such as Deep LSTM, Convolutional LSTM and Bi-directional LSTM are applied on Indian dataset to predict the number of positive cases.

Seyed Ali Rakhshan et al.[5] have proposed an optimal numerical design for estimating the system's parameters. It also introduced machine learning models to strengthen the methodology in data analysis, particularly for prediction scenarios. This study has used MLP, RBF, LSTM, ANFIS, and GRNN methods for training and evaluation of COVID-19.

Farhan Mohammad Khan et al.[6] have used three different techniques such as Decision Tree, Support Vector Machine, Gaussian Process Regression algorithm to project the criticality of COVID-19 transmission in India using GIS andmachine learning methods.

Junaid Farooq et al. [7] employed, deep learning to propose an Artificial Neural Network (ANN) based online incremental learning technique for developing an adaptive and non-intrusive analytical model of Covid-19 pandemic to analyze the temporal dynamics of the disease spread.

Moutaz Alazab et al.[8] provided a forecasting analysis of COVID-19 confirmations, recoveries, and deaths in Australia and Jordan. It further implemented a CNN-based COVID-19 detector to identify COVID-19 infections using X- ray images.

Shwet Ketu et al.[9] introduced a CNN-LSTM hybrid deep learning prediction model, which can correctly forecast the COVID-19 epidemic across India. The proposed model uses convolutional layers, to extract meaningful information and learn from a given time series dataset. It is also enriched with the LSTM layer's capability, which means it can identify long-term and short-term dependencies.

A. Ronald Doni et al.[10] has built Deep learning model by considering the features of weather and COVID-19 data (recovered, infected and deceased) for predicting the number of cases expected in India. The model is built on Concurrent Neural Network (CNN), Recurrent Neural Network (RNN), Bidirectional RNN (BRNN), Long Short-Term Memory (LSTM) and Bidirectional LSTM (BLSTM) based on the daily weather and COVID-19 data collected from Indian subcontinent.

Aman Khakharia et al.[11] have developed an outbreakprediction system for COVID-19 for the top 10 highly and densely populated countries. The proposed prediction models forecast the count of new cases likely to arise for successive 5 days using 9 different machine learning algorithms.

Vishan Kumar Gupta et al.[12] detected the COVID-19 cases, i.e., confirmed, death, and cured cases in India only. This study has performed this analysis based on the cases occurring in different states of India in chronological dates. Dataset contains multiple classes to perform multi-class classification. On this dataset, first, it performed data cleansing and feature selection, then performed forecasting of all classes using random forest, linear model, support vector machine, decision tree, and neural network, where random forest model outperformed the others, therefore, the random forest is used for

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prediction and analysis of all the results. The K-fold cross-validation is performed to measure the consistency of the model.

Hafiz Tayyab Rauf et al.[13] presented forecasting models to estimate and predict COVID-19 outbreak in Asia Pacific countries, particularly Pakistan, Afghanistan, India, and Bangladesh. They have utilized the latest deep learning techniques such as Long Short Term Memory networks (LSTM), Recurrent Neural Network (RNN), and Gated Recurrent Units (GRU) to quantify the intensity of pandemic for the near future. Authors have considered the time variable and data non-linearity when employing neural networks. Each model's salient features have been evaluated to foresee the number of COVID-19 cases in the next 10 days. The forecasting performance of employed deep learning models shown up to July 01, 2020, is more than 90% accurate, which shows the reliability of the proposed study.

Kareem Kamal A et al.[14] focused on research and applied Artificial Intelligence (AI) algorithms to predict COVID-19 propagation using the available time-series data and study the effect of the quality of life, the number of tests performed, and the awareness of citizens on the virus in the Gulf Cooperation Council (GCC) countries at the Gulf area. Authors have implemented the proposed model based on Long Short-Term Memory (LSTM) with ten hidden units (neurons) to predict COVID-19 confirmed and death cases.

Ameer Sardar et al.[15] detected the role of machine-learning algorithms in investigating various purposes that deals with COVID-19. This study has concluded that Machine Learning can be involved in the health provider programs and plans to assess and triage the COVID-19 cases. Supervised learning showed better results than other Unsupervised learning algorithms by having 92.9% testing accuracy.

Sourabh Shastri et al.[16] presented the educational perspective of Covid-19 and forecast the number of confirmed and death cases in the USA, India, and Brazil along with the discussion of endothelial dysfunction in epithelial cells and Angiotensin-Converting Enzyme 2 receptor (ACE2) with the Covid-19. Three different deep learning based experimental setups have been framed to forecast Covid-19. Models are (i) Bi-directional Long Short Term Memory (LSTM) (ii) Convolutional LSTM (iii) Proposed ensemble of Convolutional and Bi-directional LSTM network are known as CoBiD-Net ensemble.

R. Lakshmana Kumar et al.[17] developed two learning algorithms, namely deep learning and reinforcement learning, to forecast COVID-19. This article constructs a model using Recurrent Neural Networks (RNN), particularly the Modified Long Short-Term Memory (MLSTM) model, to forecast the count of newly affected individuals, losses, and cures in the following few days. This study also suggests deep learning reinforcement to optimize COVID-19's predictive outcome based on symptoms.

Shreshth Tuli et. Al.[18] applied an improved mathematical model to analyse and predict the growth of the epidemic. An ML-based improved model has been applied to predict the potential threat of COVID-19 in countries worldwide. It shows that using iterative weighting for fitting Generalized Inverse Weibull distribution; a better fit can be obtained to develop a prediction framework. This has been deployed on a cloud computing platform for more

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accurate and real-time prediction of the growth behaviour of the epidemic.

Peipei Wang et. al.[19] integrated the most updated COVID-19 epidemiological data before June 16, 2020 into the Logistic model to fit the cap of epidemic trend, and then feed the cap value into FbProphet model, a machine learning based time series prediction model to derive the epidemic curve and predict the trend of the epidemic. Three significant points are summarized from modelling results for global, Brazil, Russia, India, Peru and Indonesia.

R. Sujath et al. [20] presented a model that could be useful to predict the spread of COVID-2019. Authors performed linear regression, Multilayer perceptron and Vector auto regression method for desire on the COVID-19 Kaggle data to anticipate the epidemiological example of the ailment and pace of COVID-2019 cases in India.

Rohini.M et al.[21] presented the prediction and analysis of COVID-19 using various machine learning algorithms. In the present study, ML-based enhanced model is implemented to predict the possible threat of COVID-19 all over the world and the algorithms used in these models classifies the COVID patients based on several subsets of features and predicts their likeliness to get affected to this disease. This model uses 20 metrics including the patient's geographical location, travel history, health record statistics, etc., to predict the severity of the case and the feasible outcome.

[3] Comparative Analysis

This study compares the performance of deep learning algorithms to predict COVID-19 cases, as shown in Table I

Table I: Comparative Analysis

Reference	Deep Learning Algorithms	Data Source	Forecasting Accuracy
Jayanthi Devaraj et al. [1]	ARIMA, LSTM, SLSTM and Prophet	country and city-specific case study for India and Chennai	SLSTM model is better performed than other models
Lu Xu et al.[2]	CNN, LSTM, and the CNN-LSTM	Data of three highly impacted countries: Brazil, India and Russia.	LSTM model has the best performance based on the results of evaluation metrics MAE, R^2, and EV.

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Ganesh Yenurkar et al.[3]	two deep learning procedures, ResNet model and GoogleNet model, are hybridized to achieve the prediction process	Data was gathered from the open-source data GitHub (https://github.c om/Akibkhanday/Meta-data-of-Coronavirus).	proposed hybrid deep learning method is valuable in corona virus identification and future mortality forecast study.
Parul Arora et al.[4]	Recurrent neural network (RNN) based long short term memory (LSTM) cells are used as prediction models. . LSTM variants such as deep LSTM, convolutional LSTM and bi- directional LSTM models were used.	32 Indian States	Based on prediction errors, bi- directional LSTM gives the best results. bi- LSTM gives very accurate results(error less than 3%) for short-term prediction (1–3 days).
Seyed Ali Rakhshan et al. [5]	ANFIS, RBF, LSTM, MLP, and GRNN.	the released data on COVID-19 by WHO for Italy, Germany, Iran, and South Africa between 1/22/2020 and 7/24/2021	ANFIS and RBF perform better than other methods in training and testing zones.
Farhan Mohammad Khan et al. [6]	Decision Tree, Support Vector Machine, and Gaussian Process Regression algorithm	Data regarding the number of cases reported in India till 10th June 2020, were collected from the Ministry of Health and Family Welfare (MoHFW) and https://www.C OVID19india.org	The model architecture is optimized using Exponential GPR that showed the best performance with the least RMSE 124.38 and the highest coefficient of determination values (R^2) of 0.95
Junaid Farooq et al. [7]	ANN	India's five worst hit states.	The simulation results suggest an alarming rise in the num- ber of cases in coming weeks with flattening of infection curves still far from sight
Moutaz Alazab et. Al [8]	Prediction models such as the PA, ARIMA, and LSTM algorithms were used		PA Delivered the best performance. and obtained prediction

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	to predict the number of COVID-19 confirmation s, recoveries, and deaths over the next 7 days		accuracies of 99.94%, 90.29%, and 94.18%, respectively.
Shwet Ketu et al.[9]	CNN-LSTM hybrid deep learning prediction model, which can correctly forecast the COVID-19 epidemic across India	data from the Arogya Setu App and the MoHFW (Ministry of Health and Family Welfare), GoI (Government of India), have been extracted on a day-to-day basis. The records used for this study are from the period 30/01/2020 to 10/6/2020.	proposed CNN-LSTM hybrid deep learning model performed exceptionally well throughout the experiment as compared to the other well- grounded time series forecasting models.
A. Ronald Doni et al.[10]	deep learning algorithms on RNN, CNN and BRNN with LSTM and BLSTM	The data set related to weather reports (Weather Data Set https://www.wu nderground.co m/; Kaggle 2020; github 2020) and COVID-19 (COVID-19 Data Set: https://github.c om/CSSEGISandData) is collected from the various sources on day wise starting from January 2020 onwards.	By considering the climatic conditions and population in India, the algorithm BRNN provides an enhanced result when compared with the other models.
Aman Khakharia et al. [11]	The proposed prediction models forecast the count of new cases likely to arise for successive 5 days using 9 different machine learning algorithms	The dataset of the countries, namely, Bangladesh, India, China, Pakistan, Germany, Nigeria, Ethiopia, Democratic Republic of Congo, the Philip-pines, and Indonesia have been used	The highest accuracy of 99.93% was achieved for Ethiopia using Auto-Regressive Moving Average (ARMA) averaged over the next 5 days. ARIMA gave an accuracy of more than 85% most of the time for almost all countries.
Vishan Kumar Gupta et al.[12]	performed forecasting of all classes using random forest, linear model, support vector machine, decision tree, and neural network.	The dataset consists of features of COVID-19 data which are taken from https://www.ka ggle.com/sudalairajkumar /covid19-in- india/ and also from the Ministry of Health & Family Welfare. The dataset consists only of 2342 samples of COVID-19 cases in India from 30 January 2020 to 26 May	random forest model outperformed the others.

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		2020.	
Hafiz Tayyab Rauf et al.[13]	latest deep learning techniques such as Long Short Term Memory networks (LSTM), Recurrent Neural Network (RNN), and Gated Recurrent Units (GRU) to quantify the intensity of pandemic for the near future.	The data set used for the training and testing of deep learning models are taken from the standard WHO website which is organized trained RNN, LSTM, and GRU with COVID-19 cases from 01-22-2020 until 06-21-2020.	The forecasting performance of employed deep learning models shown up to July 01, 2020, is more than 90% accurate, which shows the reliability of the proposed study.
Kareem Kamal A et al.[14]	simple Long Short-Term Memory (LSTM) model with an input layer, a single hidden layer, and an output layer that is used to make a prediction	The created series of prediction and forecasting models based on time-series data to check when the situation will be under control in the GCC countries at the Gulf area (KSA, UAE, Oman, Bahrain, Kuwait, and Qatar)	obtained results from the LSTM models have confirmed that KSA and Qatar would take the most extended period to recover from the COVID- 19 irus, and the situation will be controllable in the second half of March 2021 in the other countries
Ameer Sardar et al.[15]	the studies used different machine-learning algorithms in different countries and by different authors but all of them related to the COVID-19 pandemic	In this study, the dataset of Covid-19 has been taken from the official website of the World Health Organization (WHO)	supervised learning is more accurate to detect the COVID-19 cases which were above (92%) compare to the unsuper-vised learning which was mere (7.1%)
Sourabh Shastri et al.[16]	Bi- directional LSTM, Convolutional LSTM, ensemble of Bi-directional and Convolutional LSTM known as the CoBiD-Net ensemble.		The pro- posed CoBiD-Net ensemble outperforms the other two models and scored high accuracy and MAPE for the forecasted cases of Covid-19.
R. Lakshman a Kumar et al.[17]	LR and LSTM.	Data from January 30, 2020 (when the first case of COVID-19 was registered in India) to August 16, 2020, were analyzed, with 75% data employed for	Based on the outcomes, the recommende d MLSTM-DRL has a lowest error rate matched to other systems.

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		practice and 25% for predictive and validation purposes.	
Shreshth Tuli et al. [18]	improved mathematical modelling, Machine Learning and cloud computing to predict the growth of the epidemic proactively.	The dataset available at https://github.c om/owid/covid-19-data/tree/master /public/data/	Using the proposed Robust Weibull model based on iterative weighting, proposed model is able to make statistically better predictions than the baseline. The baseline Gaussian model shows an over- optimistic picture of the COVID-19 scenario.
Peipei Wang et al.[19]	hybrid Logistic and Prophet model, a machine learning based time series prediction model to derive the epidemic curve and predict the trend of the epidemic.	experiments for forecasting the trend of COVID-19 in global and particular countries based on the epidemiological data (form January 22, 2020 to June 16, 2020) are conducted to analyze the effectiveness of our proposed model.	As the research in this paper shows that a hybrid Logistic and Prophet model has a valuable advantage in terms of forecasting the epidemic trend.
R. Sujath et al[20]	We have performed linear regression, Multilayer perceptron and Vector autoregressi on method for desire on the COVID-19 Kaggle data	COVID-19 Kaggle data to anticipate the epidemiological example of the ailment and pace of COVID-2019 cases in India. Anticipated the potential patterns of COVID-19 effects in India dependent on data gathered from Kaggle.	MLP method is giving good prediction results than that of the LR and VAR method using WEKA and Orange

[4] SUMMARY

From the results shown in Table 1, it has been observed that different types of deep learning algorithms were used by various researchers to forecast the COVID-19 cases. Researchers have experimented with deep learning algorithms such as stacked long short term memory (SLSTM), long short term memory (LSTM), Bi-directional LSTM, CNN-LSTM,ANFIS, RBF, RNN, exponential GPR, Decision Tree, Random Forest, Support Vector Machine, ARIMA etc. to get the best forecasting performance of machine learning models. This study concludes that SLSTM deep learning algorithm performed best as compared to other algorithms.

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