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Information Technology

# COVID VIRUS PREDICTION IN TURKEY USING ARTIFICIAL INTELLIGENT ALGORITHMS

**Aymen Imad Mustafa ALAZOW**

Master`s Thesis

Supervisor

Asst. Prof. Dr. Ayça TÜRKBEN

Istanbul, 2023

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The thesis titled COVID VIRUS PREDICTION IN TURKEY USING ARTIFICIAL INTELLIGENT ALGORITHMS prepared by AYMEN ALAZOW and submitted on 14/04/2023 has been accepted unanimously/by majority of votes for the degree of Master since in Information Technology.

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Aymen Imad Mustafa ALAZOW

Signature

# DEDICATION

I am so grateful to God for giving me the strength and motivation to complete my master's thesis. Without His guidance and support, I would not have been able to persevere through the challenges and setbacks that inevitably arose during the process. I also want to express my deep appreciation to my father and mother for their constant encouragement and for believing in me even when I didn't believe in myself. A special thank you goes to my wife for her unwavering love and support. She was always there for me, offering words of encouragement and helping me stay on track. Finally, I want to thank my friends Ahmed Salem, Zaid Al-Aaraje, and Radwan Al-zerary for their encouragement and for being there for me during this journey. I could not have done it without their support and friendship.

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# ABSTRACT

## COVID VIRUS PREDICTION IN TURKEY USIN ARTIFICIAL INTELLIGENT ALGORITHMS

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COVID-19, also known as the coronavirus, has had a major effect on the planet. As countries and governments seek to mitigate the spread out of the virus and protect their citizens, many are turning to artificial intelligence (AI) algorithms to help predict the spread and trajectory of the virus. In Turkey, AI algorithms have been utilized to analyze data on the spread out of COVID-19 and make predictions about its future trajectory in the country. (ML) and (DL) are two examples of AI algorithms being utilized for COVID-19 prediction in Turkey. AI algorithms can analyze big data that would otherwise be difficult for humans. By analyzing data on the spread of the virus, including factors such as the number of cases, the rate of transmission, and the performance of public health measures, AI algorithms can make more accurate predictions spread of the virus. The research plan consisted of several steps, the first of which was preparing a Covid data set for the country of Turkey since the beginning of the disaster in 2020. AI algorithms were used for the prediction process, such as:

RF, ARIMA, LSTM, and RNN using the Python programming language.

In general, the use of artificial intelligence algorithms to predict COVID-19 in the Republic of Turkey to help reduce the spread of this epidemic among the population. By analyzing data on the spread of the virus and making accurate predictions, AI algorithms are helping decision-makers in Turkey make informed decisions about how to best respond to the COVID-19 pandemic. As the ARIMA model outperformed the other algorithms utilized in this study, the study's findings can be trusted in the field. The following values were the error measures for this model and the execution time. For the Arima model: (MAE=592.647), (RMSE=1007.816), (MAPE=0.084), (MASE=0.470), and (Time = 0.14 s).

**Keywords:** Artificial Intelligence Algorithms, COVID-19 Pandemic, Turkey, Arima, Deep Learning, Lstm.

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# ABBREVIATIONS

| | | |
|---|---|---|
| AI | : | Artificial Intelligence |
| RF | : | Random Forest |
| ACF | : | Auto-Correlation Function |
| PACF | : | partial Autocorrelation Function |
| ARIMA | : | Auto-Regressive Integrated Moving Average |
| RNN | : | Recurrent Neural Network |
| DL | : | Deep Learning |
| LSTM | : | Long Short-Term Memory |
| ML | : | Machine Learning |

# 1. INTRODUCTION AND PURPOSE

Here, the Covid-19 disease will be discussed, its risks, and how this epidemic has affected all countries of the world and Turkey in particular, then Artificial Intelligence (AI) in the medical field and its importance in predicting the Corona pandemic will be discussed.

## 1.1 BACKGROUND

The world faced an invisible threat in the past years and to this day in the form of a virus that, despite its small size, has killed more than a million people globally[1]. the World Health Organization (W.H.O.) gave the virus the name COVID-19 [2]. In the Chinese city of Wuhan, instances of the novel coronavirus first emerged in December of the 2019 year [3]. In China alone, the total number of patients has increased significantly to 74 283 as of February 19, 2020 [4]. Covid 19 disease spreads by contact or mixing between people or by coughing from respiratory droplets flying on people or on the surfaces of tangible things transmitted by touching the hand to the nose or eyes, these methods accelerate the transmission of infection between people and sometimes appear on the infected person Symptoms and some of them do not show any symptoms. This virus is a member of the SARS family [5]. However, this virus affects the person in 2 to 14 days. Dry cough and severe attacks of shortness of breath are some of the symptoms of this disease [6]. Anosmia has recently been identified as one of the symptoms of a coronavirus infection [7]. In (Figure 1.1) shows the distribution of countries' cases of the Corona pandemic from (www.worldometers.info) and last updated: November 05, 2022, 15:49 GMT.

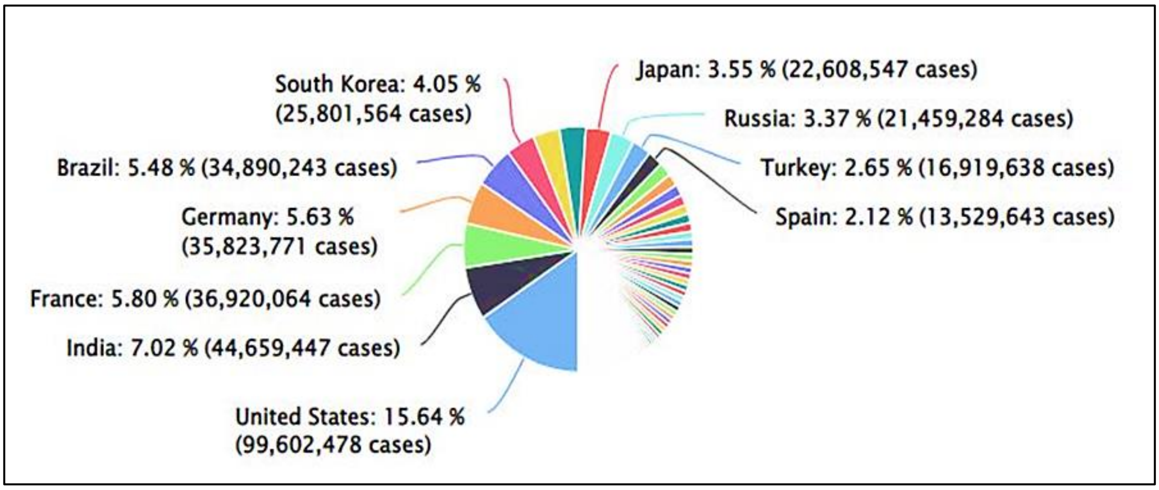


**Figure 1.1:** Distribution of Corona Cases in Some Countries [8].

This disease quickly spread among people when it was discovered, leaving the world with insufficient time to prepare for it. Because it spread among individuals and resulted in a significant number of deaths worldwide, the World Health Organization deemed it an emergency [9]. The Corona outbreak is seen as a worldwide disaster since it has had a significant impact on daily life, curfews have been implemented in the majority of countries, and some have decreased factory output. In many nations, it has a bad effect on the future. Following the declaration of states of emergency, the closure of markets, schools, universities, and all modes of transportation, as well as the imposition of curfews, the Corona epidemic also directly impacts human life [10], It has led to a global condition of dread and terror, an economic downturn, and psychological strain on individuals all over the world. After the Corona epidemic became a global event and was declared a deadly global epidemic, the national and international global organizations and the World Health Organization published preventive and awareness instructions among people to limit the spread of this disease [11]. These recommendations and instructions by organizations included preventive measures that target this epidemic, reduce its spread, and protect the human world. Despite the widespread adoption of these guidelines, the majority of nations were unprepared to deal with the Corona outbreak and instead depended on citizens' initiatives and education about the disease and ways to prevent infection. Despite being relatively easy to implement, the most crucial steps attempted to limit the Corona pandemic are hand cleanliness, sterilizing public spaces and touchable surfaces, mask use in crowded areas, and patient isolation. Alpha, delta, beta, gamma, and Omicron variations of the virus are novel strains of Covid-19 disease that have emerged as a result of the illness's rapid transmission among humans [12]. On November 26, 2021, SARS-COV2 (Omicron) strain was discovered and reported for the first time in South Africa[13]. Then, after the spread of this epidemic among humans, a new mutant of the Covid-19 strain appeared, called Omicron. Nearly 40 countries, including Britain, the Netherlands, and America, reported the emergence of the new mutant on December 5, 2021[14].

### 1.1.1 Covid-19 In Turkey

Turkey reported its first instance of the Covid 19 sickness on March 10th, 2020[15], and on March 13, 2020, 4 infected cases were announced, bringing it to 2433 out of a total of

33,004, and in 14 days from the 25th of the third month of 2020, The death rate due to the epidemic was calculated (59) cases, estimated at (2.4%) [15]. Day 24 of the outbreak saw a total of 125,556 tests, 18,135 positive cases, and 356 deaths, in comparison to other cities, Istanbul has the most instances (8852) followed by Izmir (853), Ankara (712) and Konya (584) [15]. It is worth noting that there are three waves that the country of Turkey passed through during the period of the Corona epidemic [16], as follows: (the first wave) The first week of December 2020 marked the high for the number (219,546 confirmed cases with 1,494 deaths), Spring 2021 witnessed the second wave, with 414,312 positive cases and 2,493 deaths, and (the third wave) began in July 2021, when the number of cases started to rise again; It reached an advanced stage of increase in January 2022 (712,091 positive cases with 1,922 confirmed cases of death).

Although the guidelines and measures to combat the Corona epidemic were published by the Turkish Ministry of Health, The Republic of Turkey stated the suspension of flights from other countries, the closure of borders with neighboring countries, and the establishment of field hospitals there [17], it has witnessed a rise in the number of infections and deaths to this day, with an increase and a decrease in the data rate, as shown (figure 1.2) (a) Active Case: All positive cases from the beginning of the epidemic until November 03, 2022, (b) Total Deaths: All deaths from the beginning of the epidemic until November 03, 2022, (c) Total Case: All registered cases from the beginning of the epidemic until November 03, 2022.

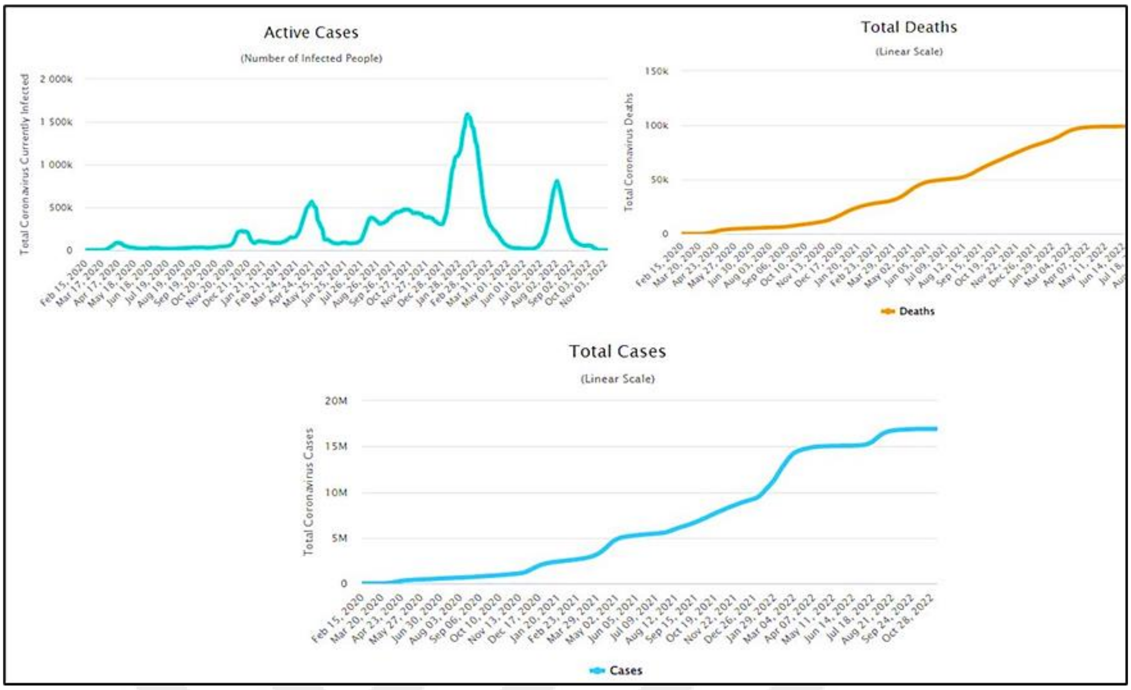


**Figure 1.2:** (A) Active Cases, (B) Total Death And (C) Total Case [18].

There are some applications that the state of Turkey has followed to limit the spread of the Corona epidemic [19], closing schools and universities and heading to e-education, because these places are overcrowded with students and are vulnerable to disease transmission among them, closing all religious and personal gatherings of events, celebrations, football matches, and cinemas Ensuring the preparation of a health concept and comprehensive health care to protect citizens from providing the necessary equipment and medicines, providing places to accommodate patients or isolating them and following them from their homes for cases that do not require admission to the hospital by the health sectors and quarantining all contacts. To stop the development of this pandemic in Turkey, it is important to express appreciation and thanks to all parties involved in all sectors of society in general and the health sector in particular for their valuable contributions to assisting patients and their country.

### 1.1.2 The Critical Role of AI In Dealing With COVID-19

AI, especially nowadays, is useful in the health field, especially for epidemiologists and doctors [20]. The medical field contains large and diverse amounts of data useful in AI for predictive diagnosis. By applying its algorithms, AI will advance the medical industry and provide physicians with a good and accurate diagnosis of their patients. Here is the crucial query for all scientists and researchers: How many individuals are expected to contract the disease, pass away, or get well throughout the pandemic and until it is eradicated? [21], To understand the behavior of this pandemic and provide answers to these issues, AI research, especially prediction science, may be applied to this subject. Prediction is done by selecting data and fed into AI algorithms so that preventive measures are taken through those results. To understand this data and make it easier to understand and act on it well, especially in the prediction process, data science which is part of AI plays an essential role in understanding that data [22]. A danger to addressing this pandemic and the challenge of halting its growth is the issue of hospitals being overburdened with patients, the demanding duties of physicians and nurses, and the paucity of medical supplies and testing equipment for the Covid-19 assessment Covid19. The confusion between human experiences in the field of medicine and predictive AI algorithms represents a good solution to confront this epidemic and limit its spread. AI is therefore somewhat comparable to human reasoning, and as a result, it is crucial to find forecasts for future accidents, fatalities, or cases of illness cures since this knowledge will be valuable in the far future. These factors may serve as a summary of how AI was used in the COVID-19 epidemic[23]:

a. Early infection identification and diagnosis: AI can quickly assess symptoms that people experience after contracting this disease, alerting both sufferers and medical authorities [24].
b. keeping track of the therapy: By creating neural networks to extract the characteristics of this sickness, it can track the care given to the injured and keep track of their medical needs[25].
c. Predicting injuries and deaths: Through the data of the injured, he can predict cases of infection and deaths and predict their spread among the countries and regions that are most prevalent for this disease.
d. Development of vaccines and drugs: By examining readily available COVID-19 data, AI is applied in drug development research. It may be faster in developing or discovering vaccines than what the normal development in pharmacology offers, which may be difficult for humans [26]. He has an effective role in discovering or developing a vaccination for corona disease [27].

e. lowering the workload for healthcare professionals: Due to the wide spread of the epidemic around the world, AI models may reduce the burden on the medical staff [28]. It gives students and medical professionals the greatest knowledge on this new disease and aids in early diagnosis and early treatment utilizing digital techniques and decision science [29].

### 1.2 THESIS PROBLEM

Global figures show that more than (638,619,088) individuals became sick when the Corona outbreak spread over the world, (6,608,633) people passed away, and (618,393,230) people were treated globally, In Turkey, the country that the study will focus on, there have been (16,919,638) infections, (101203 deaths), and (16,785,602 recoveries), according to the official website (www.worldometers.info/coronavirus). When looking at those horrific statistics, the world may stand to confront and limit the spread of this epidemic, each according to its specialization. The issue here is how to control new infections and prevent them from spreading among people, especially cases of death, as the loss of a loved one or friend has social and psychological repercussions and cases of recovery where the patient can recover, but some people suffer from side effects after recovery. The epidemic also hurt the global economy as a whole, with some countries' economies collapsing entirely as a result of the recession caused by the pandemic. Curfews were enacted in many countries during the peak of the Corona epidemic, and the lack of preparedness at the outset of the pandemic and the resulting increase in human gatherings contributed to the spread of the disease. In response, the field of health AI has been introduced, and its techniques are used to better understand the disease and find ways to mitigate its effects and predict cases, death, and recovery.

### 1.3 THESIS AIM

This study aims to use AI to stop the Corona pandemic from spreading by doing the following:

a. The epidemic in Turkey will be managed and combated in the future, and the human and economic disasters brought on by this epidemic will be lessened by forecasting injuries, fatalities, and recovery over the next year.

b. The country of Turkey can gain from this research by better comprehending the virus's transmission, raising public awareness, and beginning to assist medical professionals.

c. Forecasting is crucial in making critical decisions such as whether to open universities, schools, places of worship, workplaces, etc. to a large extent. The prediction may also help in establishing vaccination and treatment strategies.

## 1.4 CONTRIBUTIONS

In this work, three models based on ML and DL algorithms were created using the Python program and the algorithms RF, ARIMA, RNN, and LSTM .The models' accuracy levels were compared, and the best model for forecasting for the following years in Turkey using long data from the start of the epidemic in Turkey on (25/03/2020) to (31/05/2022) was determined, this is to know and analyze the spread of this epidemic for the future period and how to preserve people's lives and take future measures.

## 1.5 THESIS LAYOUT

In addition to what was presented in the first chapter, the study's subsequent chapters will be layout as follows: Chapter 2 reviews some of the previous work, an introduction to artificial intelligence, and a theoretical discussion of algorithms. in Chapter 3, The forecasting procedure, research data, and the development of predictive models employing clever algorithms are all covered. In Chapter 4, the models are evaluated, the results are reviewed, and the best model is selected. The final chapter, Chapter 5, provides various recommendations for future research as well as the conclusions reached.

# 2. PREVIOUS STUDIES AND GENERAL INFORMATION

In this chapter, previous works will be listed and then a brief overview of AI and some of its techniques related to this research topic will be presented. Then, the algorithms that will be worked on are presented by explaining them theoretically, and their types, advantages, and disadvantages.

## 2.1 PREVIOUS STUDIES

Kumar et al. 2020 [30] Ten nations that saw the epidemic's growth, including Spain, Italy, Germany, France, the United States, Iran, Russia, India, the United Kingdom, and Turkey were predicted to see cases of infection in the far future, two algorithms, the ARIMA model and the Prophet, were used, and the data was used for the period from January 22, 2020, to May 20, 2020. The models composed of the two algorithms were evaluated by (MAE), (MAPE), (MSE), and (RMSE) showing that ARIMA is superior to Prophet in the prediction process for the data followed, the results were good, but at the time of the pandemic, Corona data were scarce, and only data for five months were used, this study showed that ARIMA is superior to Prophet in the prediction process for the data followed.

Singh et al. 2020 [31] Five nations Spain, United States, the United Kingdom ,Italy ,and France were predicted using two algorithms (ARIMA and (LS-SVM), The (LS-SVM) algorithm was shown to be more accurate in daily scenarios, and (MAE), (MSE), (RMSE), and (R2) were utilized to determine the results' validity and compare them to the actual outcomes, in this study, predictions were produced for a single case—new infections—during only one month.

In Cabras et al. In 2021 [32], An algorithm (LSTM) was used to predict the spread of infection in Spain as an input to a Bayesian model, and the researcher claimed that it is difficult to assess the accuracy of this hybrid process and these models.

Didem Guleryuz 2021 [33], The author used the patient's data for Turkey for the following fifteen days to apply three models from the (EXPOS), (LSTM), and (ARIMA) algorithms. The prediction results for each model were compared, and it was discovered that the ARIMA model, which includes various parameters, provides the most accurate predictions. It was projected for only fifteen days, from May 17 to May 31, however in terms of the total number of cases, it ended up being the best, their growth, new infections, deaths, and their growth rate.

Sandipan Banerjee and Yongsheng Lian 2021[34], It turns out that the rate of injuries decreases when wearing a mask, especially while mingling, and that the LSTM network was used to detect a model that predicts new daily injuries that affect people through mingling, For similar earlier works for various nations, including Turkey, Italy, Canada, Egypt, Australia, United Kingdom, Brazil and Japan, his model was compared to the ARIMA model, The researcher's model is superior to the prior model, ARIMA, which made the same prediction on those countries, according to the calculation of the RMSE for the comparison procedure between the two models, Other cases, including death and recovery, have not been treated; Focus only on new cases.

Ipek Atik 2022 [35], A type of long-term memory algorithm (Bi-LSTM) was used with data on injuries, deaths, and recovery for the time from 12,2,2021, to 1,12, 2021, for republic Turkey, however, the data was sparse and covered only eleven months, and the findings of the model analysis had a high correlation coefficient (R) of 98%.

Pınar CİHAN 2022 [36], Machine learning regression algorithms based on data for the country of Turkey include random forest, k-nearest neighbors, bagging, vector regression support, and classification and regression tree with an error rate of 13.4%, the RF model was found to be the best, only 124 days of data were used, and divided into two groups for training and testing, yielding 9.2% and 2.9%, respectively, for the total numbers of infected and deceased.

Marcus Carpenter et al. 2021 [37], The data used is only 28 days to be used in the forecasting process for the number of cases, and the results showed that the value of RMSE is small, which is 23% better, A model made from GRU and RNN is responsible for predicting the time series of data for several countries for the period from 03/30/2021 to 27/04/2021.

Güneş GÜÇLÜ et al. 2022 [38], The model the author presented to predict the occurrence of an illness in Turkey using LSTM has an accuracy rate of about 89% on (R) measurements. Data was collected between March 11, 2020, to March 24, 2021. Although the data set also included numerous prediction areas, such as mortality and recovery, only one model was utilized to forecast injuries without being compared to other algorithms.

Gülhan Toga et al. 2021[39], Artificial Neural Networks (ANN) and (ARIMA) models are employed in Turkey to forecast infected cases, fatalities, and recoveries, compared two technologies using statistical measurements like MSE and SSE, The findings reveal that in terms of prediction, ARIMA and ANN perform about equally well, As a result, In this study, it was shown that ARIMA has high prediction accuracy, where R values are quite high for propagation prediction, Epidemiological data was used in Turkey before the stage of the Corona vaccine, so data collection and analysis in that time is also important.

## 2.2 INTRODUCTION OF (AI)

AI is the study of creating intelligent machines using software to make them smart to the point where people understand and solve some complex problems that can sometimes challenge humans or complement or complement human intelligence in performing some work [40]. AI can build intelligent robots that act and think like people and can make their judgments thanks to the field of AI in computer science [41]. AI was initially introduced and released in 1950[42], but several issues have prevented it from being widely adopted and used. John McCarty launched the field of AI in 1956 at the Dartmouth Summer Research Project on AI, a conference that bears his name [43]. AI was created by researchers in the years that followed to define techniques, discern human behavior, make medical diagnoses, and create various games. Some examples of AI are search engines on the web such as Google, social networking sites and recommendations such as Netflix, YouTube, and Facebook, communication programs with smartphones such as Siri, smart cars such as Tesla, and also enter into some smart electronic games such as chess[44]. Artificial intelligence can be implemented using a wide variety of methods, including deep learning, machine learning and neural networks, its offshoots, and many more. The themes that we'll be using in this study will be briefly discussed, as seen below (Figure 2.1).

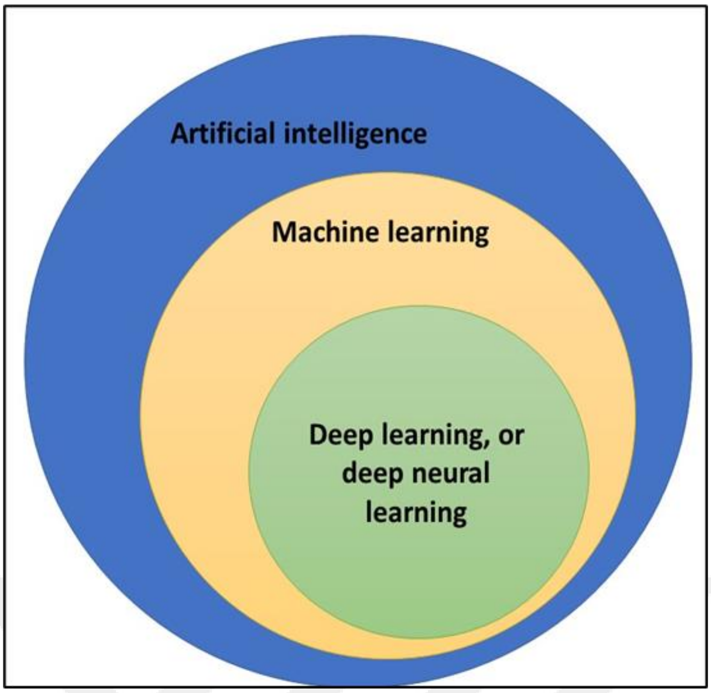


**Figure 2.1:** Type of AI.

Artificial intelligence (AI) is a computer science research field, coined by the American scientist John MacCarthy in 1956, whose aim is to build computers that imitate human intelligence when performing tasks. One of the primary goals of AI is learning. Machine Learning (ML) and Deep Learning (DL) are two of the main learning areas in AI. ML is the use and development of algorithms that are able to learn and adapt automatically through experience and by the use of data, algorithms and statistical models to analyze and draw inferences from patterns in data. Supervised learning algorithms, in particular, build a model based on sample data, known as training data, in order to make predictions or decisions without being explicitly programmed to do so.Deep learning is part of a broader family of learning methods based on artificial neural networks in which multiple layers of processing are used to extract progressively higher level features from data. Deep learning architectures include deep neural networks, deep belief networks, deep reinforcement learning, recurrent neural networks and convolutional neural networks

### 2.2.1 Machine Learning (ML)

is a subfield of AI that deals with designing algorithms that let computers pick up on patterns or behaviors from experience [45] using specific samples known as datasets,

which can be made up of text, numbers, or other types of data [46]. ML is classified into four types:
Supervised learning: The algorithm is trained on the labeled data so as to predict the output of the new unseen data based on the patterns learned from the training data and solve the regression problems, where a certain numerical value is anticipated, for example, forecasting changes in temperature or electricity consumption, and solving classification problems, where the outcome is a classification for a given class, for instance, if the email is spam or legitimate, or if the tumor is malignant or benign [47]. are examples of supervised education.

Unsupervised learning: where the algorithm is trained on unlabelled data and the goal is to discover hidden patterns or relationships in the data. Unsupervised learning unearths information buried in the data that it uses as an input to conclude itself. Clustering is one of the most widely used examples of this type of learning. Uses of clustering include gene sequence analysis, market research, and other things[48].
Semi-supervised learning: The algorithm is trained on a mixture of labeled and unlabeled data, and the objective is to use unlabeled data to augment the labeled data in order to increase the accuracy of output predictions.
Reinforcement learning: where the algorithm learns to make decisions by interacting with an environment, receiving rewards or penalties based on the decisions it makes. The objective is to maximize the long-term cumulative return. This allows the ML model to experiment with the goal-accomplishing process on its own using trial and error to maximize reward. Electronic games are one area where reinforcement learning methods have been used [49].

Artificial neural networks (ANN) [50] can be discussed, which are significant due to their adaptability and ability to be modified for many situations for ML types. ANNs are composed of mathematical representations of interconnected processing units known as artificial neurons that are based on the information processing of biological systems. Similar to how synapses in the brain and therefore each link between neurons exchange messages between them [51]. As shown (Figure 2.2), the normal neural network consists of different layers, the first is the input layer and is responsible for any information entering the network, the hidden layers are responsible for performing mathematical operations and calculations, and the last layer is the output and is responsible for the final results.

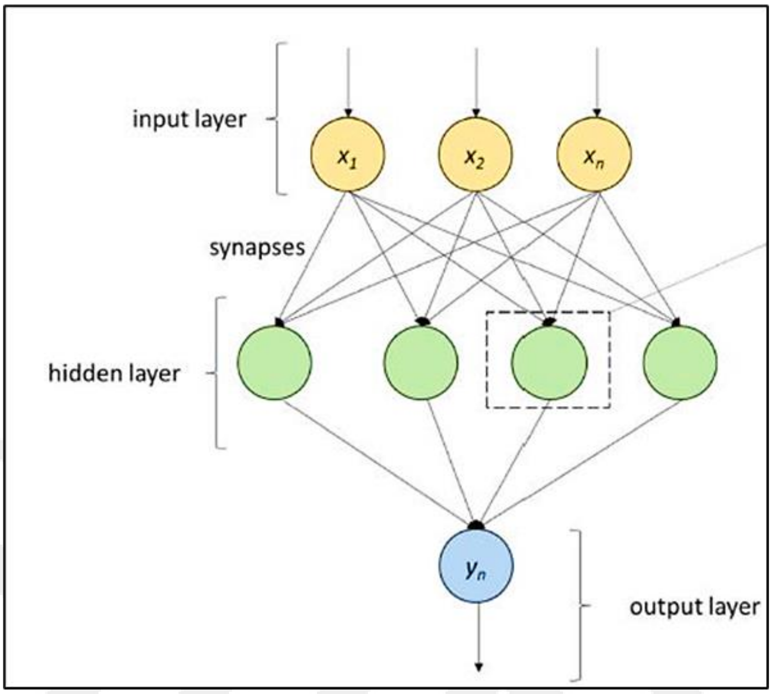


**Figure 2.2:** Neural Network (NN) [52].

### 2.2.2 Deep Learning (DL) and Neural Networks (NN)

Machine learning, which uses computer algorithms to learn, advance, and evolve on its own, includes Deep learning. DL architectures contain deep neural networks (DNN), convolutional neural networks (CNN) and recurrent neural networks (RNN)[52]. Deep learning's advantage over traditional ML techniques [53]. As was previously mentioned that neural networks contain three layers. Its difference from deep neural networks or deep learning is that it contains several hidden layers [54], one or more, (Figure 2.3) as shown in. The hidden layers perform mathematical operations on the data entered into them [55] produce Including data transmitted to the output layer, or it can be repetitive and repeat itself, such as the RNN and LSTM algorithm adopted in our research.

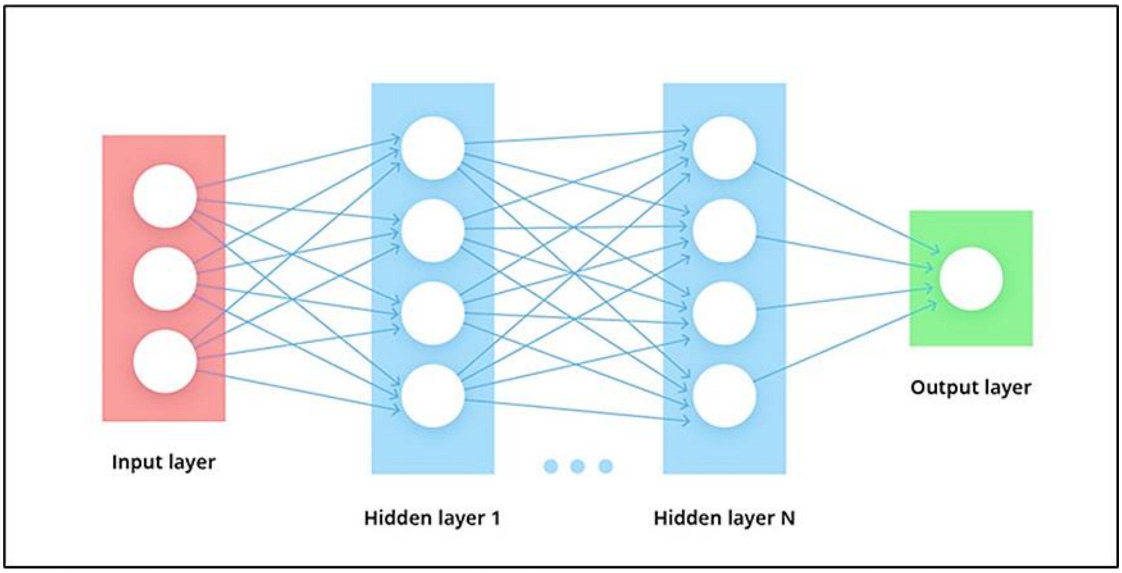


**Figure 2.3:** Deep Learning and Layers [56].

Deep Learning (DL) gives promising results in time series data analysis and forecasting. DL models are capable of learning the temporal dependencies and structures like trends and seasonality in the data automatically. Multi-Layer Perceptron (MLP) can handle multivariate inputs and can be used for multi-step forecasting. Feed Forward Neural Networks (FFNNs) with sparse representation can be useful for time series prediction. Convolutional Neural Networks (CNNs) are used for automatic feature learning and can support multivariate inputs and outputs for time series forecasting. ML and DL models play a major role in accurately predicting the progression of diseases. The features of data with high dimensionality, without error or noise, must be extracted. The ubiquitous nature of multivariate data can be handled by RNNs to predict the temporal dependencies in the time series data and these can also identify the missing patterns in the data which improves the prediction accuracy. This section describes the necessary concepts of time series forecasting models like RF, ARIMA, LSTM and RNN, used in this study for forecasting the pandemic COVID-19 outcomes.

### 2.2.3 Forecasting Methods

The act of forecasting involves making future predictions based on the past. The previous data or information of a time series is analyzed using forecasting methods or algorithms to forecast the future patterns or consequences of these data or time series. The process of forecasting involves estimating the magnitude of uncertain future events and drawing numerous inferences from a variety of assumptions. It consists of two types: qualitative forecasting, which includes types that will be discussed later, and quantitative forecasting, which also includes types. Decision-makers need to know which methods are best for their industry because not all of them would be effective for forecasting. Forecasting may be advantageous in many industries where future projections must take future conditions into account. Forecasting is crucial for the energy business. Academics and business experts have authored thousands of researches on forecasting energy prices and consumption as well as the production of renewable energy for example, wind and solar energy [57], and for the health sector, A ML approach for real-time COVID-19 epidemic predictions in 2019–2020 combining news alerts, internet searches, and estimations from mechanistic models [58], and it includes many fields. It is of two types:

a. Qualitative Methods: These methods rely on expert judgment and subjective opinions to make predictions. They are often used in situations where data is scarce or unreliable. Examples of qualitative methods include the Delphi method, scenario building, and judgmental bootstrapping.

b. Quantitative Methods: These methods use mathematical models and algorithms to make predictions based on historical data. Examples of quantitative methods include time series analysis, ARIMA modeling, exponential smoothing, and machine learning methods.

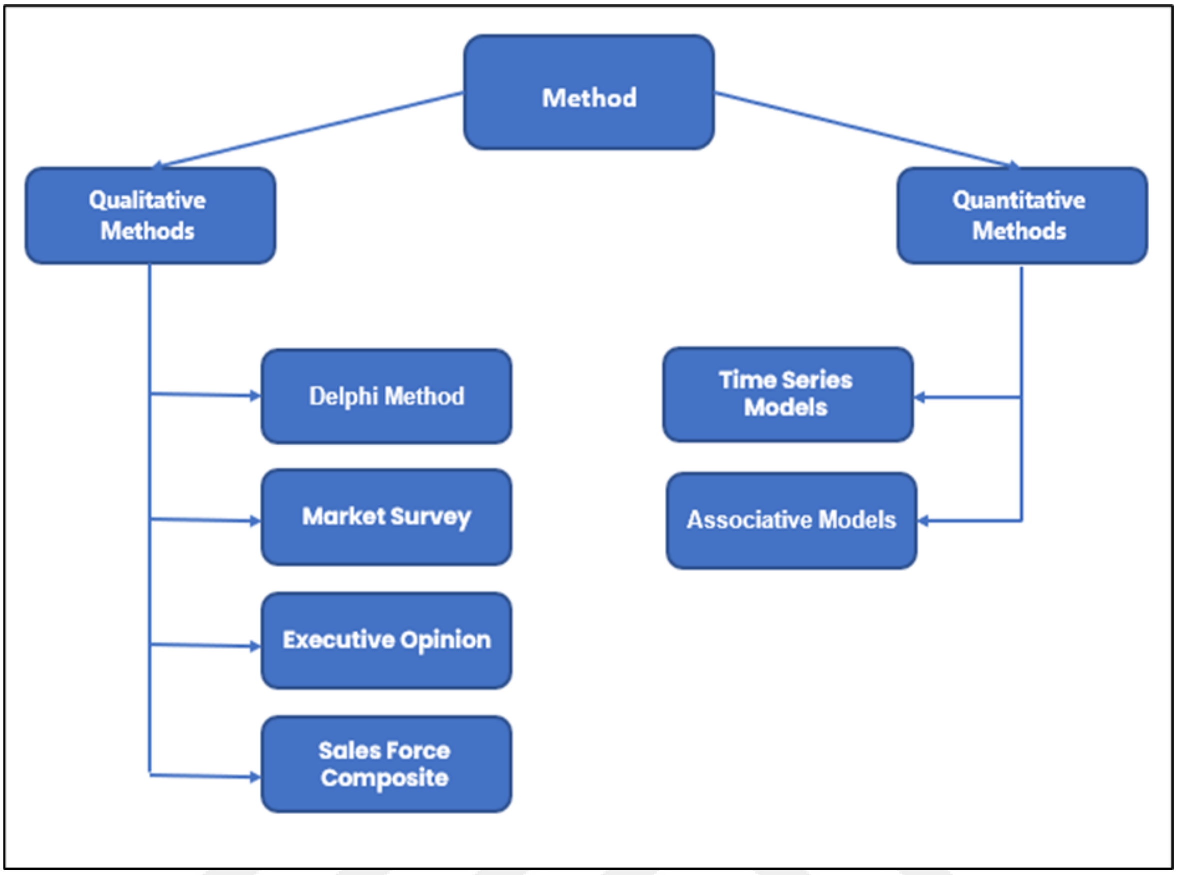


**Figure 2.4:** Types of Forecasting.

We will discuss Time Series and their use and types in connection with our study and help define some of the terms that will be covered later. Time series are groups of quantities collected at equal intervals, while the frequency of time series is the time during which data is collected. Time Series At the beginning of the seventies of the twentieth century, there was a growing amount of interest in the analysis of time series and techniques for predicting their future values. It has been regarded as one of the most important statistical methods for forecasting across a wide range of applications and scientific disciplines. When scientific theories are founded on past information about time, time series become predictable. The time series is just a collection of consecutively made notes across time [59]. The creation of mathematical models that adequately describe the sample data is the major goal of time series analysis [60]. The results of the previous data, it is used for conclusions and play an important role in producing results in the future. Forecasting time series is not always ideal for all circumstances. Therefore, there are four basic components of any time series that must be addressed, namely:

a. Seasonality: Another time series data characteristic that can be seen in time series charts is seasonality. When time series data reveals predictable patterns at intervals less than a year, this is known as seasonality. The data changes as the time series expands or contracts at a predictable rate based on a particular time cycle, such as daily, monthly, or yearly. the amount of road traffic increases in the morning but decreases at night, etc. This data is called seasonal. Retail sales is an example of a seasonal time series (Figure 2.5), which rises or falls during certain periods.[61].

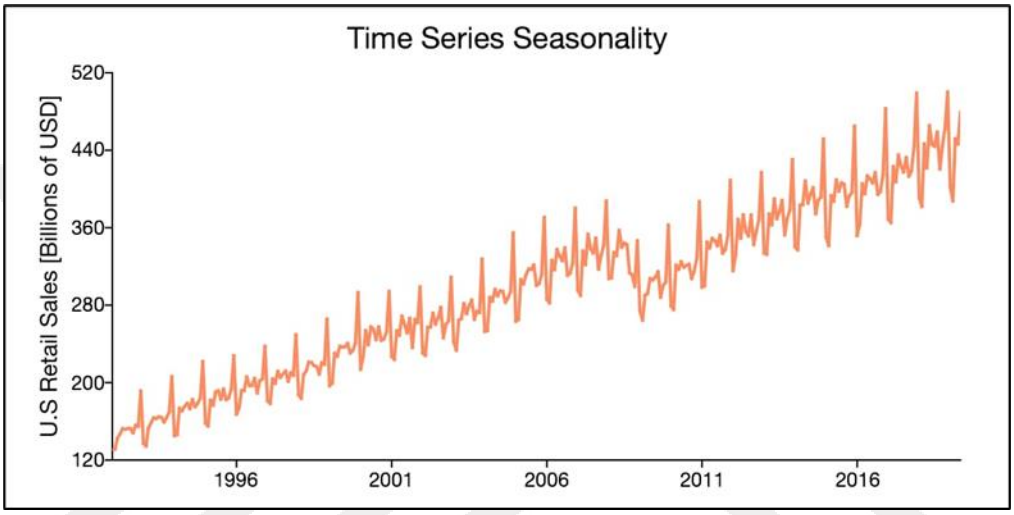


**Figure 2.5:** Time-Series Seasonality for Retail Sales [61].

b. Trend: It is called a time series general trend if it shows growth, reduction, or stagnation in the data over a lengthy period. As a result, define a trend as a rise, reduction, or stability of data within a certain time series. With increasing time, the trend may change direction sometimes [62]. A time series plot that looks like it centers around an increasing or decreasing line, an example (Figure 2.6) below, showing what the time trend looks like.

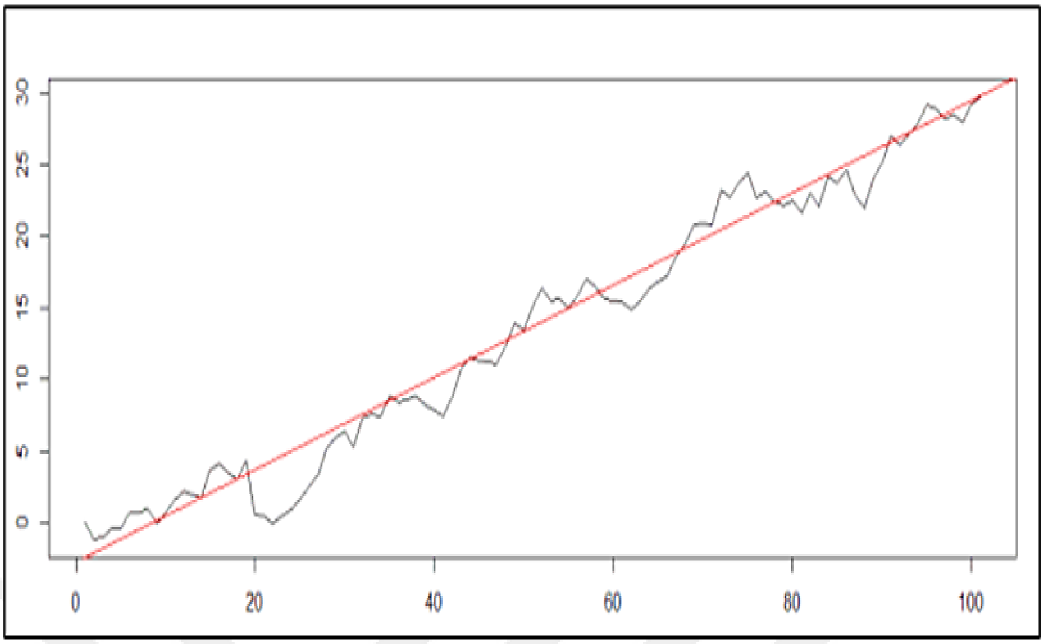


**Figure 2.6:** The Trend [63].

c. Cyclical: When the data shows statistics with increases and decreases with a larger time sector, it is cyclical. These differences often last for at least two years, As shown in (Figure 2.7).

d. Irregularity: Irregular or random variations are caused by unexpected forces on the data in the time series and are irregular and cannot be repeated in a specific model [64], Events like war, strikes, earthquakes, floods, and revolutions, among others, are to blame for these variations. (Figure 2.7) also shows irregularity.

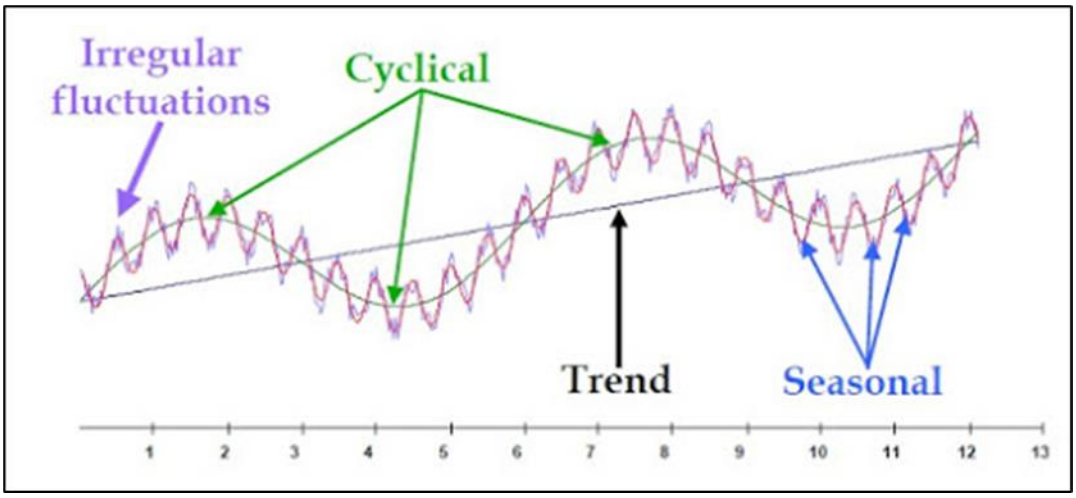


**Figure 2.7:** Components of Any Time Series [65].

There are some definitions related to the time series that will be put forward:

a. Stationary Time Series: If there is no growth or skew in the data, the time series is considered to be constant; thus, the variance and mean are constant with the timeline, making it simple to forecast future values.

b. Non-stationary Time Series: It is called an unstable series because the variance and the arithmetic means are unstable. Most time series are unstable.

## 2.3 ALGORITHMS

In the second section, the algorithms used in the research will be explained, as their types, and their advantages and disadvantages.

### 2.3.1 Random Forest (RF)

In 1995, Tin Kam Ho created the first RF algorithm. RF is an ensemble ML algorithm that is used for regression and classification. It is predicated on the notion of building numerous decision trees and fusing their forecasts to yield a more accurate outcome. This algorithm provides precision, adaptability, and accessibility [66]. It is used in regression and classification, and it produces several decision trees during the training phase [67]. The input data is entered randomly, and the properties are also randomly sorted, which is why it is called random. The fact that not all features of a data set are used consistently for a single decision tree is problematic because these features may be crucial to interpreting the data set and influencing the intended outcomes. For a trustworthy identification of essential components, the RF technique is suggested [68]. Among the uses of the RF algorithm for prediction in many medical fields including, in India, for fifteen states it predicted total confirmed cases COVID-19, total treatments, and total deaths due to this epidemic [69]. It was used by the researcher to show that the weather is one of the main reasons for increasing the infection and death rates of the Corona pandemic, such as humidity, winds, and even temperatures [70], It has also been used in the following research on water distribution in the Taihu Lake Basin/China, with good results to help projects restore water quality in that area [71]. As for the use of RF in classification, studies have been conducted in the medical field, including lymphatic classification [72], and in the field of network security and penetration, intrusion patterns were automatically generated on the training data, and then new interventions were detected by the RF algorithm [73] It can be used in network security, especially the wireless sensor network, to enhance the ability and detect intrusions [74].

**Table 2.1:** Advantages. and Disadvantages of RF.

| **Advantage** | **Disadvantage** |
|---|---|
| Ability to handle high-dimensional data: With a lot of input variables, Random Forest can still produce reliable predictions. | The algorithm can be computationally expensive This is because each tree in the ensemble must be grown and trained, and the predictions must be made by combining the predictions from all of the trees. This can lead to long training times and high computational requirements, especially for large datasets or when using large ensemble sizes. |
| Robustness to overfitting: Random Forest uses an ensemble of decision trees, which helps to reduce the risk of overfitting. This indicates that the model generalizes well to new, unforeseen input and is less likely to memorize the training data. | In large projects, RF could use a lot of memory since it employs several decision trees, this prevents it from making decisions and may slow it down compared to some other, more efficient algorithms. |
| Ease of use and interpretability: Random Forest is a relatively simple algorithm that is easy to implement and understand. This makes it an attractive choice for many practitioners and researchers. | Random forests can sometimes produce overconfident predictions, especially when the ensemble size is large and the trees are highly correlated with each other. In these cases, the algorithm may be too confident in its predictions and may not be sufficiently sensitive to changes in the input data. |
| Ability to identify important features and variables: Random Forest can rank the importance of input variables and help identify which variables are most strongly associated with the output predictions. | |

### 2.3.2 Auto-Regressive Integrated Moving Average (ARIMA)

Popular time series forecasting technique ARIMA is used to model and estimate future values based on past data. It is expressed by the following equation:

$$Y_t = \phi 1\, W_{t-1} + \phi 2 W_{t-2} \dots \dots \ldots \phi_p W_{t-p} + \ e_t + \theta 1 e_{t-1} + \theta 2 e_{t-2} + \cdots + \theta q e_{t-q} \quad (2.1)$$

Two statisticians, George Box, and Guillaume Jenkins published it for the first time in 1970 [75]. That is why it is sometimes called Box Jenks. It is adaptable to various time series data formats and forecasting precision [76]. Through the three main parameters, the Arima model is formed and written it ARIMA (p, d, q) [77] where:

p: The autoregressive component is the correlation between the current variable and the variable in the later periods.

d: The integrated component refers to the use of transforming the data by subtracting the past values of a variable from the current values of a variable to make the data stationary.

q: The moving average component refers to the dependency between the dependent variable and past values of a stochastic term.

The ARIMA model has been used in extensive journals to generate a long range of forecasts, and one can use it extensively in weather forecasting to prevent natural disasters such as fires and floods as it has been based on 65 years of meteorological data for India (1951-2015) Three datasets were generated from the data A training set from 1951 to 1975 a control set from 1975 to 1995 and a validation data set from 1995 to 2015 were used To verify the time series the acquired data sets were examined for trend and seasonality after which the ARIMA coefficients (p, d, q) were determined and then in the last step the prediction process was carried out and the error value was checked which was 0.0948 for rain data and 0.085 for temperature which indicated that the algorithm worked properly good [78], Energy and electricity prices can also be predicted for the next day [79], Fluctuations in demand or sales, such as predicting print newspaper demand to cut back on returns and surplus supply and prevent missed sales [80], and It has various applications in medical specialties, such as predicting cases of corona disease in India and helping medical workers to control this epidemic [81].

**Table 2.2:** Advantages. and Disadvantages of ARIMA.

| Advantage | Disadvantage |
|---|---|
| ARIMA, in the case of forecasting, only needs data from the time series being projected [82]. | The condition for the stationary of time series [83]. |
| ARIMA is also relatively straightforward to implement and interpret, which makes it accessible to a wide range of users, including those without extensive statistical training. The method is based on simple linear regression models and can be easily customized to fit the needs of a particular forecasting problem. | The ARIMA models often have significant costs because of the substantial data needs and the absence of efficient update mechanisms. |
| In comparison to many other systems, they also have the benefit of being less sensitive to the underlying assumptions concerning the nature of the data fluctuations. | Since there is no automatic update option, the entire modeling process must be repeated - especially the diagnostic scan phase, where the model may have crashed. |
| ARIMA is a widely used and well-established method for time series forecasting that offers several advantages, including versatility, simplicity, and proven effectiveness. | If the time series is not stationary, the method may produce poor predictions. In these cases, other methods, such as SARIMA or non-stationary ARIMA, may be more appropriate. |

### 2.3.3 Recurrent Neural Network (RNN)

It is a type of NN known as RNN to deal with sequential data, and its output depends on both the current input and its previous states. One of the recursive neural networks is the recurrent neural network, which shares similarities in terms of structure and dependencies[84]. It was discovered in 1986, according to the scientist David Rummelhart [85]. When communications are made between nodes in the network, a parallel graph is formed along the time series [86], RNNs are characterized by the idea of memory, depending on the details of the previous output, the RNN algorithm is characterized by preserving these details to produce the subsequent output. The data produced from past tenses are used in future tenses [87] [88]. The RNN algorithm solves problems related to traditional neural networks. It can process sequential or time-series data, taking both the newly received input and the input received from the past, and the RNN's memory can hold the entry due to its memory.

The RNN algorithm is used in many areas of practical life, Forecasting in the business [89] and time-series prediction [90], for example, earthquake prediction [91], And predicting the corona pandemic for some countries, as in the following research, where a model was made to make predictions, the linear node and the RNN algorithm were combined to process the time series and integrate the outputs of the two to lead to the desired results [92], and in scientific fields, including its use in robotics [93] and speech recognition [94] Machine translation [95] Speech recognition [96] and language modeling, etc. In the medical field, its uses are many, including numerical prediction of intra-arterial blood pressure [97], its use in detecting diseases [98], etc. It has many uses in several fields.

RNN loses memory while capturing long-range dependencies and the gradient fading problem that emerges in it, despite having a memory to return and exchange data. Each of these restrictions causes new RNN architectures of the following categories to appear:

Fully Recurrent Neural Network (FRNN) The 1980s saw the development of the fully recurrent neural network, which can learn temporal sequences either online or in batch mode [99]. Another type is the recursive neural network that relies on the same set of weights repeatedly on the network in topological order, a network with a differentiable graph-like structure is generated, Additionally, automated differentiation in reverse mode is used to train these networks [100]. Echo State Network An echo state network is one that only sometimes (about 1%) connects to the hidden layer [101]. Neural history compressor It is a stack of unsupervised RNNs. Based on understanding the previous layer's input, the subsequent level's input is projected. Inputs are passed to the next higher level with the addition of extra hidden units if they are not expected. The LSTM system overcomes the vanishing gradient problem and can learn a task using deep learning [102]. Gated Recurrent Units Kyunghyun Cho devised a gating technique for RNNs in 2014 [103], In comparison to LSTM, this mechanism has fewer parameters and no output gate.

Neural Turing Machines (NTM) In 2014 [104], Alex Graves introduced NTM. This concept combines the flexibility of programmable computers with fuzzy pattern matching. Differentiable Neural Computer DNC was released in 2016 [105] by Alex Graves, the same author of NTM, and it used an auto-associative memory model. There are many other architectures for RNN. (Figure 2.8) shows the four common types of RNN as follows:

a. One-to-One RNNs: It is the least complex type where the input and output are one vector. Based on the current entry and the previous state, the hidden state is determined at each time step.

b. One-to-Many RNNs: In this architecture, the input is a single vector and the output is a sequence of vectors. This type of RNN is commonly used in image captioning and music generation.

c. Many-to-One RNNs: In this architecture, the input is a sequence of vectors, and the output is a single vector. This type of RNN is commonly used for sentiment analysis and document classification.

d. Many-to-Many RNNs: In this architecture, the input and output are both sequences of vectors. It is used a lot in the field of translation and video classification.

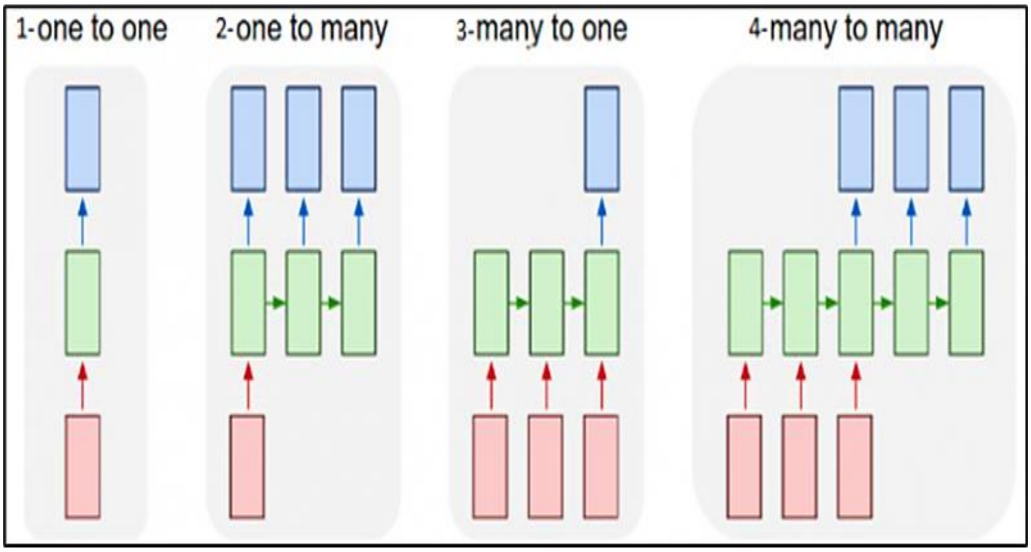


**Figure 2.8:** Types of RNN [106]

**Table 2.3:** Advantages. and Disadvantages of RNN.

| Advantage | Disadvantage |
|---|---|
| RNNs are designed to process sequences of inputs and capture the relationships between inputs over time, making them well-suited for tasks such as speech recognition and natural language processing. | Gradient vanishing/exploding, a problem with classic RNN that either stops the weights from updating or makes the model unstable, occurs when the gradient values decrease or explode during the backpropagation process. |
| The Hidden state, which retains some sequence-related information, is the primary characteristic of RNNs. | Due to its fading gradient and exploding gradation, learning long-term dependent activities in the long time series is challenging [107]. |
| Is their ability to handle variable-length sequences, which is common in many real-world applications. This allows RNNs to be applied to a wide range of sequential data, including speech, text, and time series data. | The training period might be challenging. |
| RNNs can learn complex patterns and relationships in data, which can lead to improved accuracy compared to traditional methods. | Overfitting: RNNs can overfit the training data, especially if the network is too large or the training data is not sufficiently diverse. |

### 2.3.4 Long Short-Term Memory (LSTM)

Is a type of RNN designed to address the vanishing gradient problem in traditional RNNs. LSTMs have memory cells that can store information over a long time, enabling the network to detect persistent data dependencies. They are extensions to expand RNN's memory, provide data weights, and help the RNN accept new information, ignore it, or give it enough weight to affect the results. Hochreiter Schmidhuber made the discovery in 1997 to address issues with the RNN method. RNN is very useful for learning sequential patterns, but the gradient vanishing/explosion problem makes them poor and has no long memory retention especially when the data is large [108]. RNN and LSTM differ mainly in that the latter contains a memory with a more complex structure and powerful capabilities for long-term dependency modeling [109]. There are three gates for the LSTM algorithm:

input, forget, and output gates [110], These gates determine whether to accept further inputs (the input gate), discard information that is not useful (the forgetting gate), or give it a role to influence output at the current time (the output gate).

It is suitable for classification and processing operations, and based on time series data, you can make predictions, Human Activity Recognition (HAR) It was suggested to identify human activity using the smartphone dataset and LSTM By combining it with the RNN algorithm and the CNN algorithm [111]. It has uses in several fields, such as Handwriting recognition [120], Human action recognition [113], Robot control [114], Music composition [115], Grammar learning [116] [117], Airport passenger management [118], and Market Prediction [119] and the medical field, it has many uses for Prediction in medical care pathways [120], Drug design [121] and Regarding how it handles the Corona pandemic, ten countries that were affected by the corona pandemic were used to compare the results of it with algorithms like ARIMA, support vector regression (SVR), and bi-directional short-term memory (Bi-LSTM) and predict confirmed cases, deaths, and recovery [122].

**Table 2.4:** Advantages. and Disadvantages of LSTM.

| **Advantage** | **Disadvantage** |
|---|---|
| By giving the recurrent network internal memory, which increases the stability of the network's states, it is possible to deal with the disappearing and exploding gradient problems more successfully. [123]. | The cell got more complex with the inclusion of new characteristics since the data still needed to be sent from cell to cell for evaluation (such as forgetting gates). |
| This kind of paradigm takes its cue from how people like to split knowledge down into manageable chunks to make it simpler to remember. | To train and get ready for real-world applications, you need a lot of time and resources. |
| It is useful for predicting time series based on the previous series. This improves forecast accuracy and helps make better decisions [124]. | Overfitting can be a concern occasionally. |

**Table 2.4:** Advantages. and Disadvantages of LSTM."Table Continued"

| | |
|---|---|
| LSTM is able to accept entries of varying lengths. This flexibility is particularly useful when LSTM is used to create broad forecasting models for specific clients or industries. | |

## 2.4 VALIDATION OF A PREDICTIVE MODEL

Validating any model is a final step to rely on that model and improve its development. The purpose of validation is to evaluate the model's performance on fresh, unexplored data and to assess its accuracy, dependability, and applicability to the real world. Requires the predictive model's validation:

a. Separate an initial sample into a training and validation data set. It is frequently advised to utilize between 60 and 80 percent of the initial data set for training and between 20 and 40 percent for validation. These ratios, however, are not set in stone.
b. use the training dataset to derive a model.
c. Determine the metrics to be presented and assess the model's quality using the data set's validation. The objective is to demonstrate that the model produces accurate estimates of the expected variable. Working with at least training and testing or validation datasets is required to do this. Test data will be used to prove the reliability of the model while training data will be used to build the model.

The most important error measures that were used in this research are presented here:

a. Mean Absolute Error (MAE): This is a measure of the difference between the predicted values and the true values, and it is expressed in the same units as the target variable [125]. To calculate MAE, you take the absolute value of the difference between the predicted value and the true value for each data point, and then take the mean of those absolute errors.

$$MAE = \frac{1}{n}\sum_{t=1}^{n}|A_t - P_t| \quad (2.2)$$

when n = number of data points,

A_t are real values and P_t are predicted values.

b. Root Mean Squared Error (RMSE): This is another measure of the difference between the predicted values and the actual values, but it is expressed in the units of the target variable and is more sensitive to outliers[125]. To calculate RMSE, you take the square of the difference between the predicted value and the true value for each data point, take the mean of those squared errors, and then take the square root of that mean. RMSE is generally more interpretable than MAE, but it is also more affected by outliers.

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(A_t - P_t)^2} \quad (2.3)$$

Here n = number of data points,

$A_t$ are real values and P_t are predicted values.

c. Mean Absolute Scaled Error (MASE): it is a unitless measure that compares the forecast error of a model to the error of a naïve forecast, which is simply the forecast that the value for the next period will be the same as the value of the last observed period[126]:

$$MASE = (1/n) * \Sigma(|A(t) - F(t)|)/\,(1/(n-m)) * \Sigma(|A(t) - A(t-m)\,|) \quad (2.4)$$

Where:

A(t) = time series' actual value at time t,

F(t) = time series' forecasting value at time t,

n = total of observations in the time series, and

m = total of seasons in the time series (if it is seasonally adjusted)

d. Mean Absolute Percentage Error (MAPE): It gauges the average size of forecasting errors without taking their direction into account. [126]:

$$MAPE = 100 * \frac{1}{n}\sum_{t=1}^{n}\left|\frac{A_t - P_t}{A_t}\right| \tag{2.5}$$

Where:

A(t) = actual value of the time series at time t,

P(t) = forecasted value of the time series at time t, and

n =number of observations in the time series

It is often a good idea to use metrics, to get a sense of both the magnitude and the variance of the error. This can provide insight into the model's propensity to generalize to fresh data. Using the grading scale that was employed, the best-performing model can then be picked.

# 3. METHODOLOGY

In this chapter of the research, the research methodology is practically explained in terms of explaining the prediction and how to create the predictive model, reviewing the data used, how to obtain and deal with it, and finally how to use the three predictive models based on algorithms (Random Forest, ARIMA, RNN, and LSTM) working using a language Python programming.

## 3.1 INTRODUCTION: PREDICTION AND PREDICTION MODELS

The term "prediction" was used in this study to describe the character of the Corona pandemic in the future. Prediction is a guess about the future, based on facts and evidence in the guessing process. To make future decisions, prediction involves illustrating a future event based on experience or historical data, it is one of the techniques of AI and is called regression. Additionally, it depends on the set of statistical techniques used to determine or forecast the goal based on earlier observations. If the output is a real or continuous number, we can often say that it is a regression problem. Regression in data science is mostly used for prediction.

This section of this study describes the modeling phase. The models will be trained and validated using the dataset. The fundamental goal of creating models is to train them to use artificial intelligence algorithms to deliver a specific forecast value in the future. Therefore, the models for this research will be built using the algorithms (Random Forest, ARIMA, RNN, LSTM), the model is trained by entering a specific proportion of the Corona pandemic data into the model to produce future results, and then the remaining data is input on the model for the examination process. The model is then evaluated to determine its suitability for providing accurate predictions by comparing its accuracy to crucial standard criteria. As a result, (Figure 3.1) depicts the model production mechanism's process and how it interacts with the data. The cycle has four phases, as can be seen:

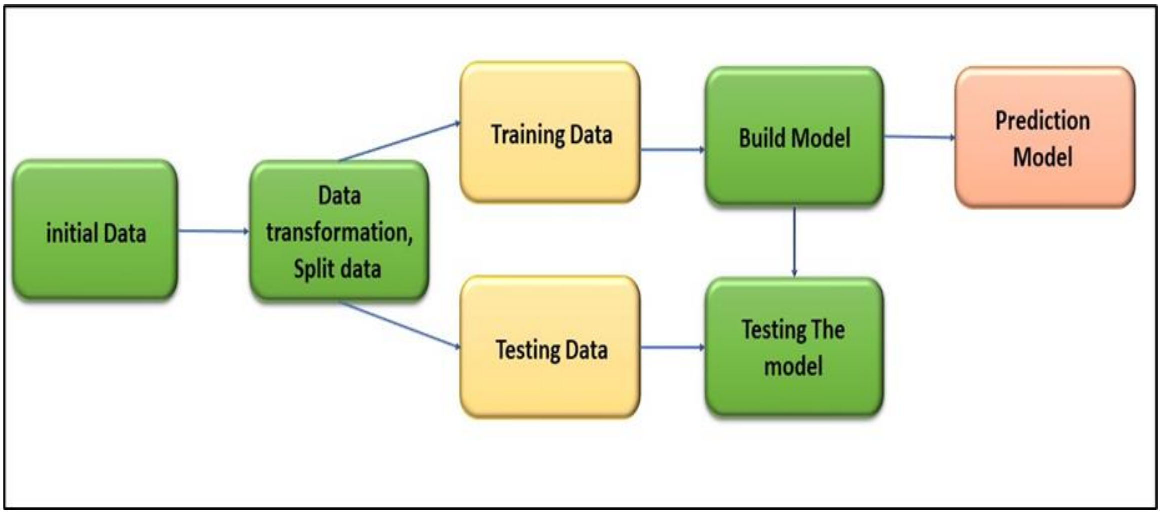


**Figure 3.1:** Building A Predictive Model.

a. Initial Data: Data is gathered from a variety of sources in the first stage so that it can be customized for the model's use.

b. Transformation and split Data: After being properly structured and having any unnecessary or empty fields deleted to conform to the method being used, the data is separated into training data and examination data. The training set is the collection of data used to teach the model how to make predictions. The model can grasp how it will operate thanks to those data. Either testing set, this set is ignored during the model training process; it is used to test the predictive data obtained by the prediction model. There is no one right approach to picking the size of the training and testing sets, hence people often utilize inductive methods like 20% test and 80% training.

c. Build the models: A tool that may be used to build a model must be available, and it should be either an open-source application or a licensed program. The Python programming language will be used to generate the models for this study. Based on predictive artificial intelligence algorithms, the model was created. The training set data is fed into this model to help it comprehend the prediction process. As for the test data set, it is to see how well the data matches reality.

d. Prediction process: The predictive results are shown through this model and are tested as mentioned in step 3. Then, using mathematical scales, the model's accuracy is evaluated. It is determined whether this model's data has a high percentage of validity, and as a result, its data is approved. This model must be monitored to be relied upon going forward, and its efficacy should be evaluated regularly. If any external changes affect the data on the ground, it could be required to update it.

A model using the random forest algorithm, a model using the ARIMA algorithm, and a model using the RNN and LSTM algorithms and by using the data of the state of Turkey for the Corona pandemic to produce predictive data for a year in the future. The optimal model is then determined by comparing the models using particular criteria that will be discussed in the fourth chapter. (Figure 3.2) depicts the general workings of the mechanism:

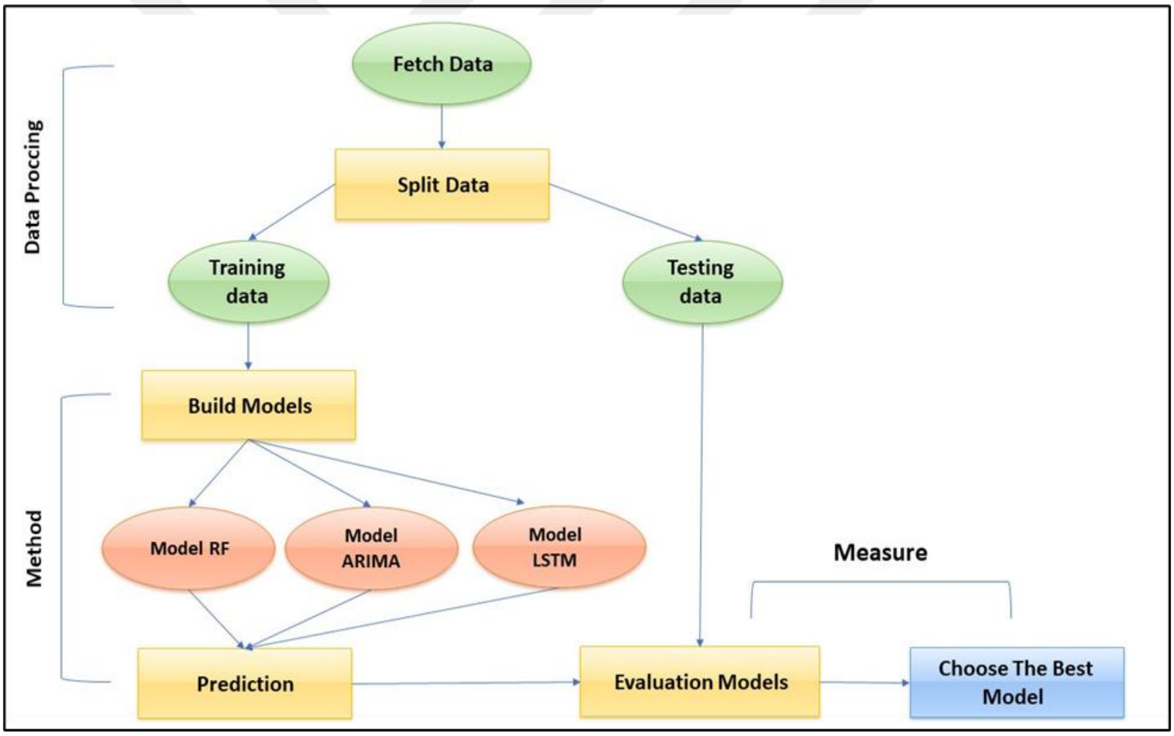


**Figure 3.2: General Working Mechanism.**

## 3.2 DATA SET

Reliable data generated by healthcare researchers are the finest weapons against misinformation. As a result, the information was looked up on electronic statistics websites, which ought to be trustworthy, and as a result, The statistics from the website (www.worldometers.info/coronavirus/country/turkey/) were chosen to provide this search with information about the Corona pandemic in the republic of Turkey, where it offers information on a variety of topics, including information in the medical sectors. As a result, the Corona pandemic data for Turkey has been downloaded for the time from (25/03/2020) to (31/05/2022) and includes date fields in the format (Day, Month, and Year), as well as the number of cases, recovery, and death, for each day, it is in the form of text data to be read by Microsoft Excel. Because empty and missing fields decrease the accuracy of the prediction results and lead to the production of inaccurate predictive data, The data set is prepared and cleaned of empty fields to initialize the forecast process.

## 3.3 METHODOLOGY

Research methodology is addressed in this section by creating three prediction models in Python, each model is dedicated to one of the artificial intelligence algorithms (RF, ARIMA, RNN and LSTM) that were used in this research.

### 3.3.1 The Main Work of The RF Algorithm

Training data is randomly entered either static or non-stationary onto its decision trees (for example, 10% of the data is entered into the first decision tree, 30% of the data is entered into the second decision tree, and so on in random proportions) The input data is equal in the division or different between trees, Random characteristics play a significant part in each of the algorithm's decision trees in producing the outcomes needed to influence data classification and prediction, Then it combines the forecasts to get a prediction that is more accurate than using just one model. As for the regression, the mean or mean expectation of the results that appeared in the overall decision trees is calculated.

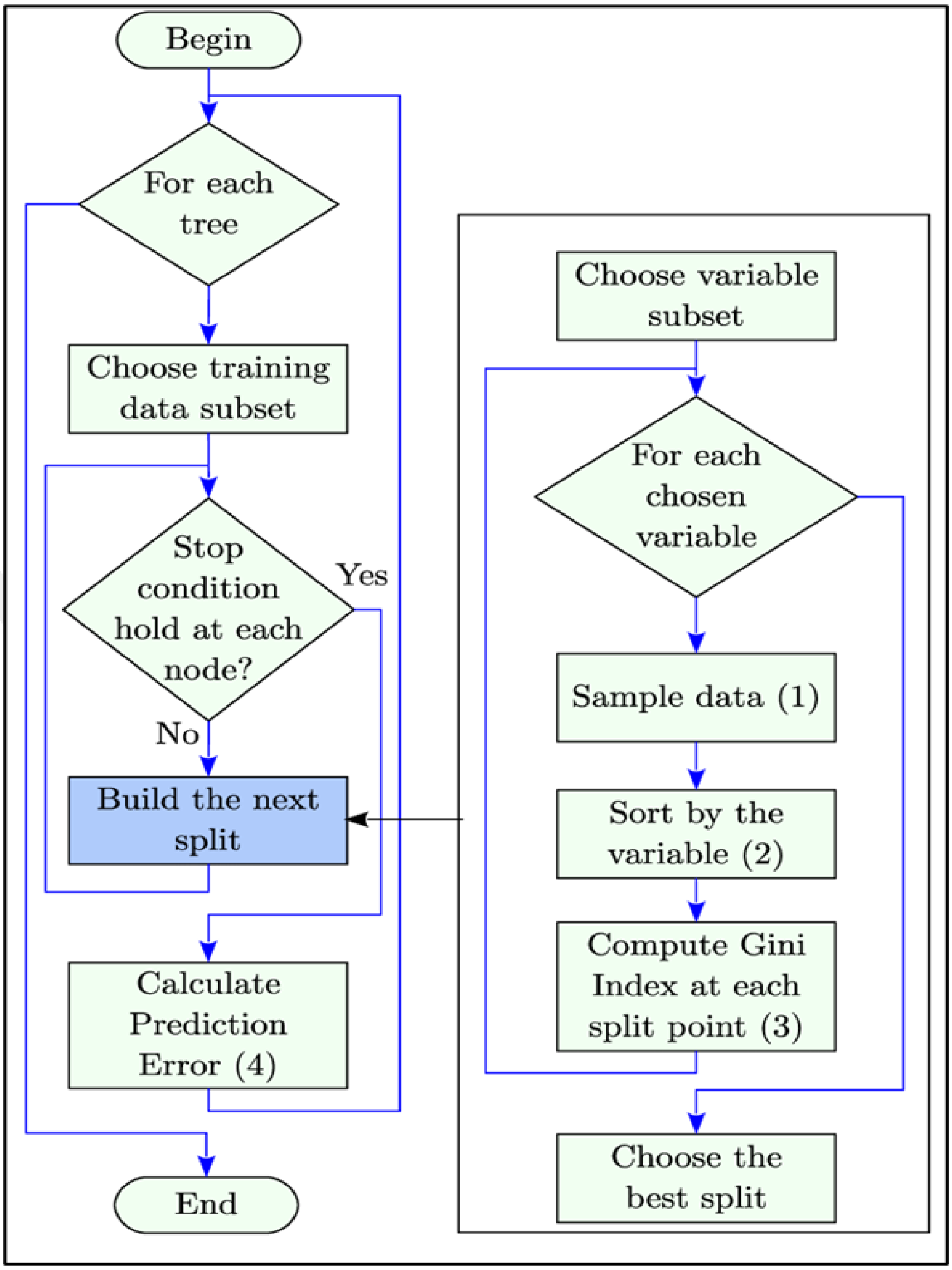


**Figure 3.3:** Flow Chart RF [127].

The fundamentals of RF algorithm training are [128]:

a. Choose n samples from a training set at random with replacement. The remaining data is utilized for "out of the bag" (OOB) training, which determines RF compatibility.

b. A decision tree is generated by randomly selecting a subset ($m < k$) from each sample with k variables.

c. Each tree expands to its maximum size with a constant M without being pruned until it is unable to be divided.

d. Following that, each decision tree's prediction or classification outcomes will be computed.

e. Results for classification or prediction are obtained by summing trees by category/voting.

f. The fundamentals of RF algorithm tasting are:

g. Feature Selection: The right order of features from the incoming data must be "observed" for the nodes of the trees.

h. Tree selection: There are currently a variety of RF classifiers available. To acquire the classifications of their labels, the fresh data for the test will be input based on the characteristics through All subgroups.

i. Bagging: To determine the total results gained, the trees selected in the previous stage (packaging method) are used.

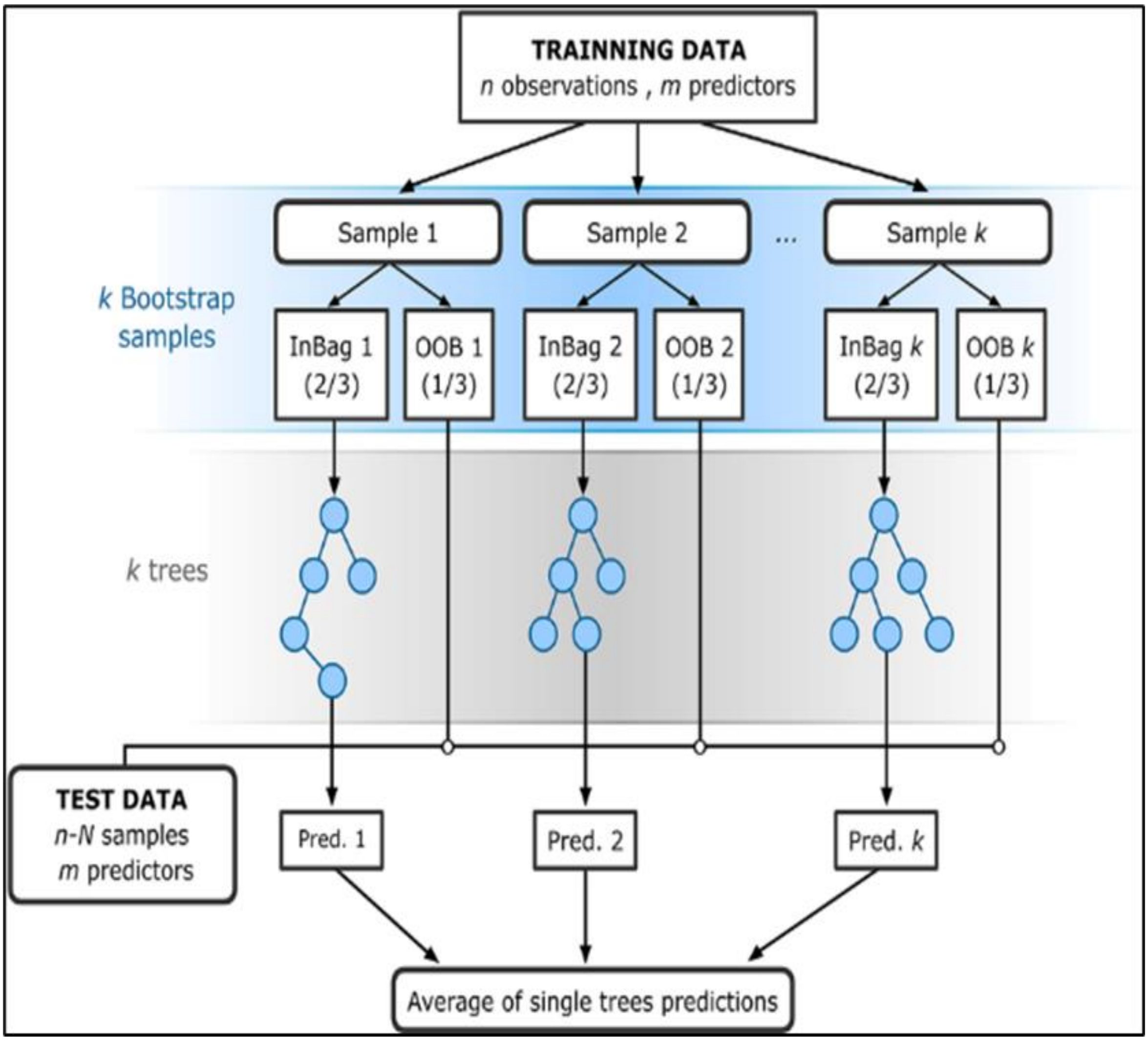


**Figure 3.4:** Training and Testing Operation [129].

The final forecast made by the RF model is seen in (Figure 3.5). The forecast made by the RF model is based on the averaged forecasts of many decision trees that are integrated into the RF model[130]. As for the final expectation, the decision will be taken by a majority vote on the results of this group. A forest with more trees has higher accuracy and doesn't experience the overfitting issue [131] Since RF theoretically has the potential to improve prediction accuracy, it has been used in this research. For regression, the following equation represents the RF forecast [132]:

$$h(x) = (1/K)\ \sum_{k=1}^{K} h(x;\theta_k) \tag{3.1}$$

where: $k \quad \infty$ Contains the law of large numbers

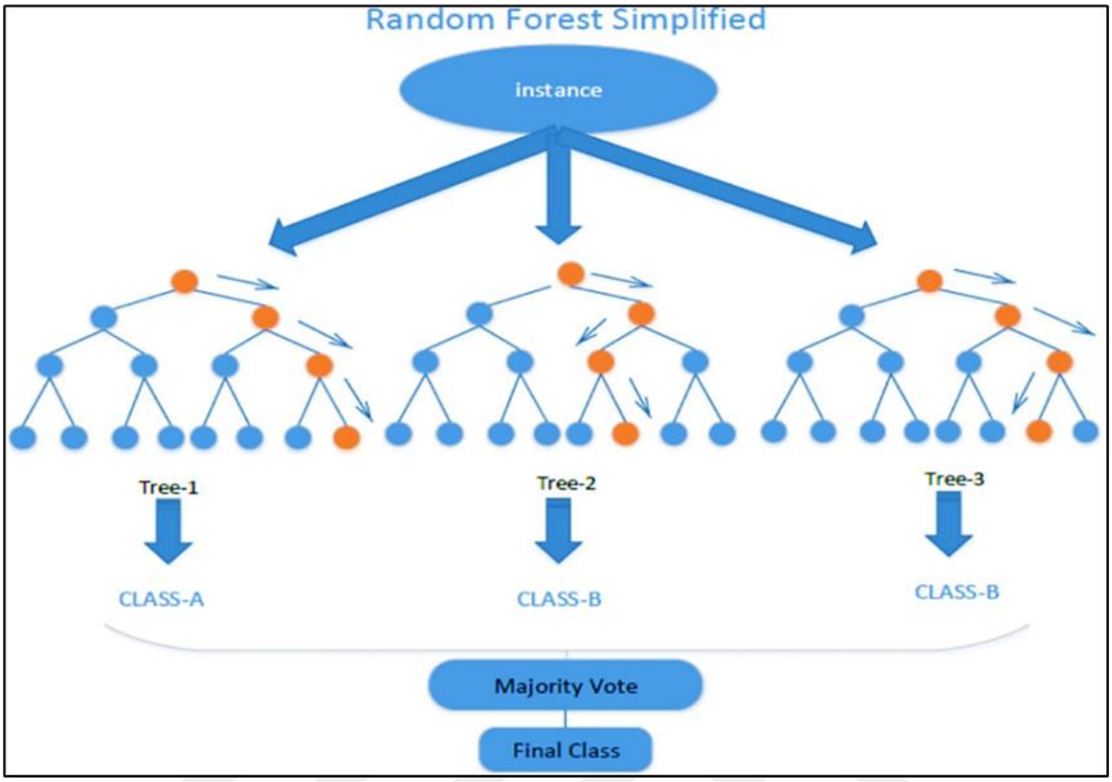


**Figure 3.5:** Structure of an RF [130].

#### 3.3.1.1 Random forest model

RF is one of the most used AI Algorithms. It is one of the algorithms based on several decision trees, which is included in the scikit-learn library in Python used in the research. The set of decision tree models or set of tree predictors is known as a random forest (RF). This code uses Python pandas and sklearn libraries to create a model that applies to cases, recovery, and deaths, separately:

The code first loads the data from the CSV file using pandas' read_csv function and drops any rows with missing values using the dropna function. Then, using sklearn's train_test_split function the code then separates the data into training and testing sets. The data is transmitted and divided into a training and testing set set by this function. Then, the script uses the RandomForestRegressor () class from scikit-learn's ensemble module to create three random forest regression models (rf_modelCasesP, rf_modeldeathP, and rf_modelrecoveredP), which will be used for predicting the target variable (cases, death and recovered) respectively. Each model is trained using 1000 decision trees with a value of “sqrt” for the parameter max_features, which means that each tree will use the square root of the total number of input features. The models are then used to make predictions about the test data, and the imports for each model are computed using the special feature_importances_ attribute. Finally, the code then prints the results for each of the three models, the code uses the trained models to make predictions for one year and writes the results to a CSV file.

### 3.3.2 The Main Work of the ARIMA

Model identification, parameter estimations, optimum model selection, diagnostics, and prediction are the stages of building an ARIMA predictive model [133], which we will discuss in detail:

a. Identification: Making sure the time series data is stationary is the first step, meaning that the mean, variance, and covariance do not change over time. This can be achieved through differencing, which involves subtracting each value from the previous value to obtain a stationary time series or check the time series' stationary. This may be done by looking at the series' graphs or studying it to see if it's stationary or nonstationary. If it is stationary, then the value of d = 0, indicating that the series has not been altered or transformed, then proceed on to the following stage. However, if it is nonstationary, we modify it mathematically to make it stable. The number of changes made to the series in this instance is the value of d [134]. These adjustments include a variety of methods, such as subtracting the value from its prior value to determine the data difference, then check the stationary of the data using the null hypothesis The ADF (Augmented Dickey-Fuller) If the null hypothesis is rejected, conclude that the time series is indeed constant, and it is a common technique for testing reliability and seasonality in time series data sets[135] [136] [137] .

b. Estimation and selecting the best model: By employing time series statistical techniques, such as Autocorrelation function (ACF) and Partial Autocorrelation Function (PACF) graphs, it is possible to define the coefficients (p & q) [138]. The linear associations between observations at various time delays are measured by ACF, in other words, ACF is used to determine if a time series data point and another point are correlated given their different times, after drawing the partial autocorrelation functions, we can establish the suitable delay times and the necessary values for the partial autocorrelation function (PACF), which is the partial correlation between the two points in a certain period [139]. To create the right forecast, the best model is picked once the parameters are determined. Despite being computationally demanding, this procedure is computer-computable. One choice is the Akaike's information criterion (AIC), which states that if two models are compared, the one with the lowest AIC is often the "better" model. This approach offers a more effective technique to select the model that will be used for the forecast [140] [141].

c. Diagnostic check: Once the parameters have been accurately estimated, ACF and PACF residuals are used to validate the prototype [142] and check the assumptions of the model to see how it stands up under deeper scrutiny. Repeat step two to locate another model that may be more suitable if the one you chose is not good enough.

d. Forecasting: The final model is used here, which is the most crucial stage since it establishes the foundation for future projections. There are two ways to forecast: either from in-sample prediction, in which case the data from the time series already in existence are predicted, or out-of-sample prediction, in which case the data are predicted for a future period of one, two, or more years. After producing a forecast, it is important to assess the model's dependability. One way to do this is to graph the produced data against the actual data; if there are few discrepancies, the prediction is more accurate. Or there are several ways to predict the validity of the model results by measuring errors such as (MAE), (MAPE), (MSE), and (RMSE).[143].

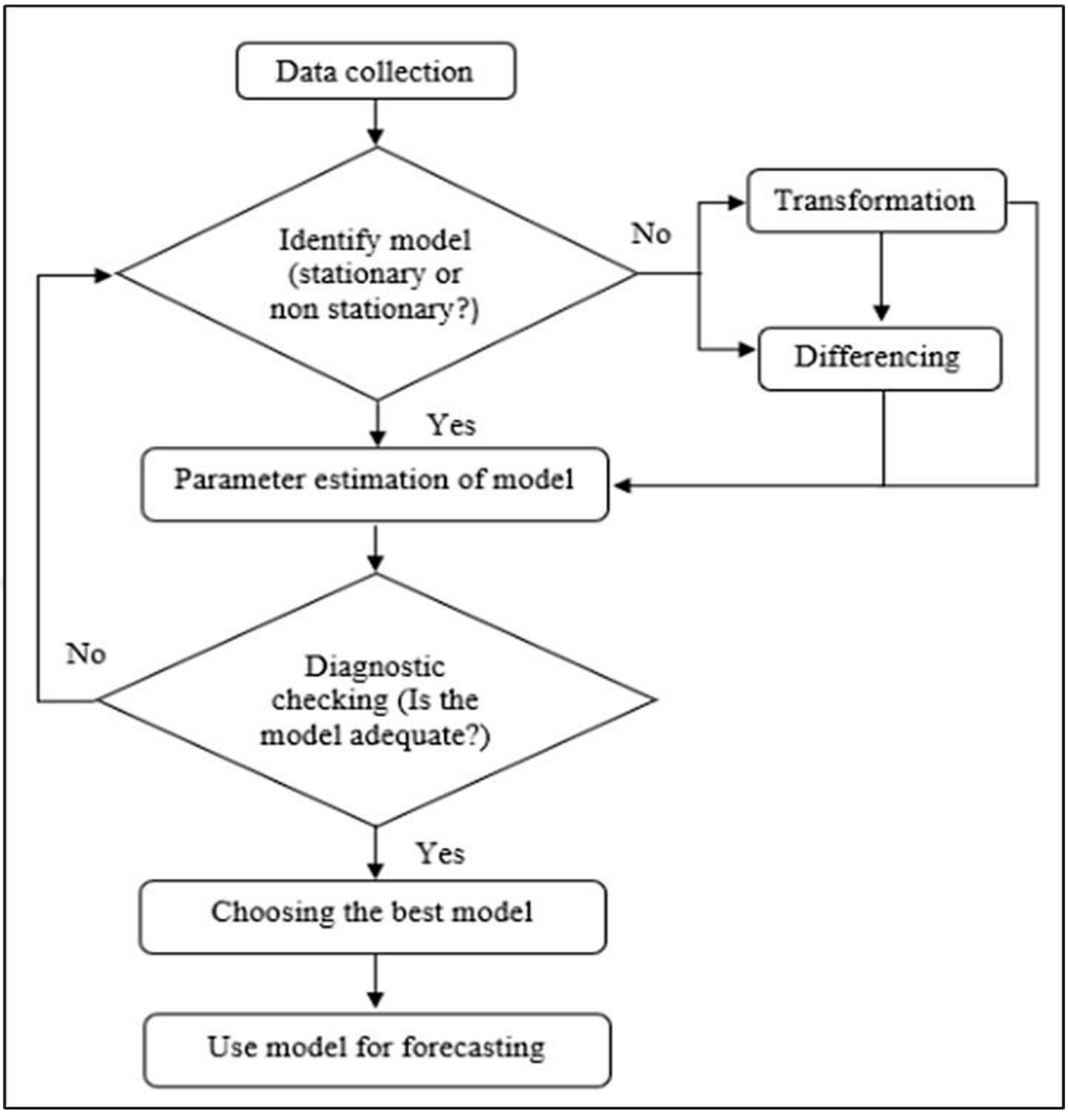

**Figure 3.6:** Flowchart for ARIMA Model [144].

#### 3.3.2.1 ARIMA model

A common method for analyzing and predicting time series data is the ARIMA model. the ARIMA model was produced in this chapter as described:

Because ARIMA only uses one variable in its prediction process, the data was initially split into three CSV files: one for confirmed cases, one for deaths, and one for cases of illness recovery. Each of these files was then further divided into training and examination data before the results were combined into one file. The script starts by importing several libraries, including pandas for working with data, matplotlib for visualizing data, and stats models for implementing time series models. Then it loads a dataset from a CSV file named "ArimaCasses.csv" into the Pandas data frame using the read_csv function. A sample of data is then shown for each case. The program from the scikit-learn library uses the train_test_split function to split the data into two training and testing sets. The split point is determined using the string length minus 234. The resulting datasets are then saved to separate CSV files using the to_csv function. Then, the script also creates a function named inverse_difference () that takes a historical dataset, a forecasted value, and an interval as input, and returns an inverted forecasted value. This function is used to convert the differenced forecasted values back to the original scale of the time series. The script then fits an ARIMA model to the differenced time series data. The ARIMA () function from the statsmodels library is used to create an ARIMA model, and model_fit = model.fit () is used to fit the model to the data. ARIMA model “order” refers to the arrangement of AR and MA components, where (p, d,q) are calculated through the programming code, where the best order is calculated, which depends on the data used, which indicates that the ARIMA model has an order of (5,1,4), which means that it has an AR component of order 5, and I component of order 1, and an MA component of order 4. Next, the program makes a multi-step prediction (for both cases, recovery, and deaths) out-of-sample that is used to forecast upcoming time series values, takes the starting and ending point of the prediction, and uses the predict () function from the ARIMA model that generates the prediction for the given time range. The performance of a model is then assessed using a variety of error metrics, including MAE, MAPE, MASE, and RMSE. Finally, the results for the three cases (case, recovery, and death) are printed separately and in CSV format for a predictive year.

### 3.3.3 The Main Work of The RNN Algorithm

Normal neural networks contain independent inputs and outputs, but there is a need to remember past data in situations where it is necessary for the prediction process for all remaining data. Thus, the RNN was created, RNN contains a "memory" that retrieves the information that has been computed, and it used the hidden layer to solve this problem and remember some information about the sequence [145], shown in (Figure 3.7).

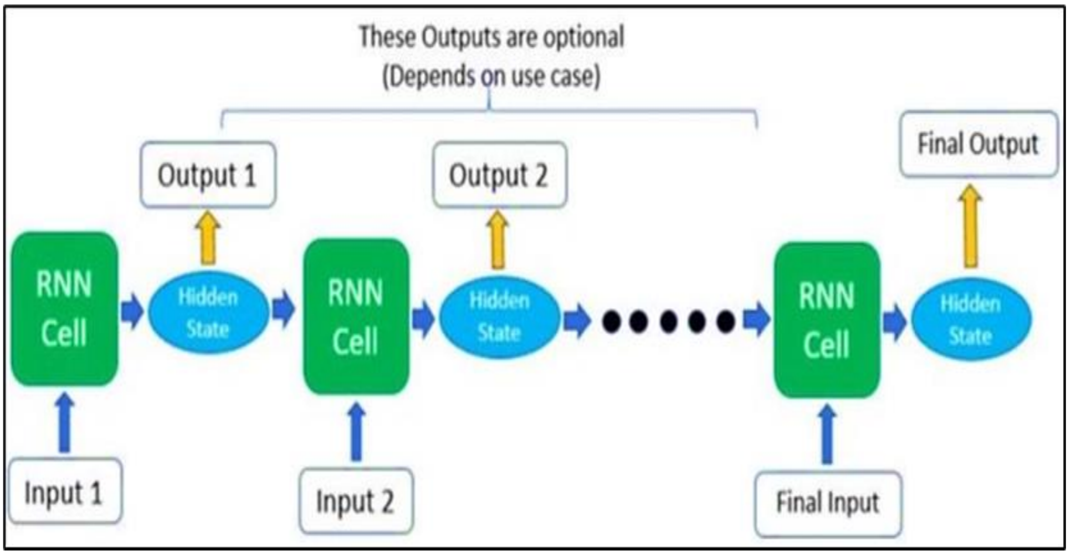


**Figure 3.7:** RNN Structure [91].

In RNN, the input layer is tasked with receiving data, processing it, and then sending it to the middle layer, which contains several hidden layers with the same configuration. Therefore, will build just one loop on top of it as many times as necessary instead of several hidden layers. The output layer distributes the probability of each piece of information to the hidden layer as its input [146]. the output of the cell will alternatively be used as the input for the subsequent cell to produce the subsequent output, and so forth for all data. When new data from the input layer enters the hidden layers, there will be a (tanh) function that will be combined with the current information inside the layer to be the output, and then it will be transferred to the next cell by forward-propagation checking whether this output is correct or incorrect to get the error if any. For backpropagation, the algorithm works backward through the different gradient layers to find errors related to the weights, and then Backprop uses these weights to reduce the error rate at training time. While more complicated neural network topologies and algorithms may improve performance, these algorithms make all calculations more difficult and lengthen training times.

The calculating the current state:

$$h_t = \mathrm{f}(h_{t-1}, x_t) \tag{3.2}$$

Whereas:

$ht$ = current state, $h_{t-1}$ = previous state, and $xt$ =input state.

The activation function's application formula **($tanh$)**:

$$h_t = \tanh(w_{hh}h_{t-1} + W_{xh}X_t) \quad (3.3)$$

Whereas:

$w_{hh}$ = weight at the recurrent neuron, and $W_{xh}$ = weight at input neuron.

the output calculation formula**:**

$$y_t = W_{hy}h_t \quad (3.4)$$

Whereas:

$y_t$ =output, and $W_{hy}$ =weight at the output layer.

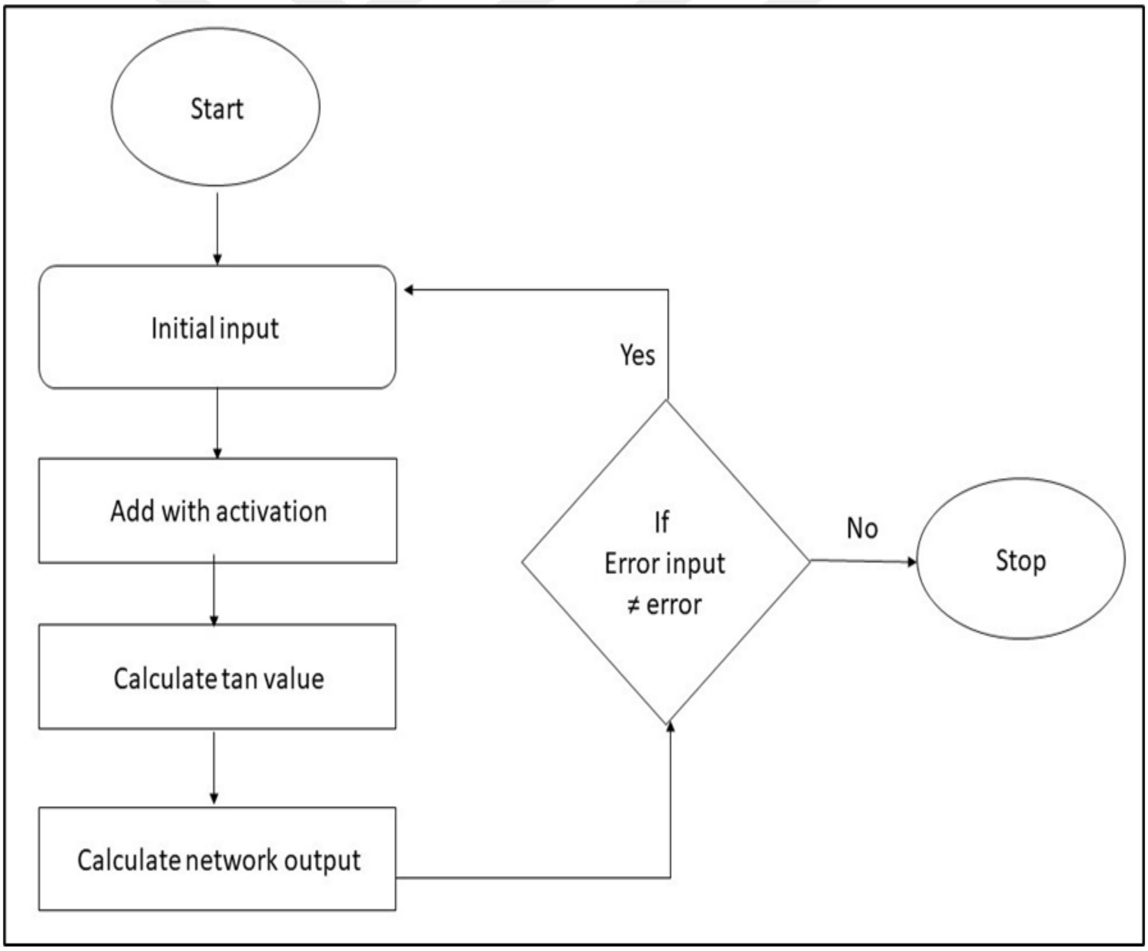


**Figure 3.8:** RNN Flowchart.

### 3.3.4 The Main Work of the LSTM Algorithm

Through gates, LSTM can remove or add information from the cell. Therefore, the purpose of the gates is to permit information to enter the cell. It also contains the sigmoid and the tanh process, so that the tanh gives values for information (1, -1) and the sigmoid gives values for information (0,1) [147], As shown in (Figure 3.9). When the value is zero, "let nothing pass" and when the value is one, "let everything pass" and so on the rest of the values are counted.

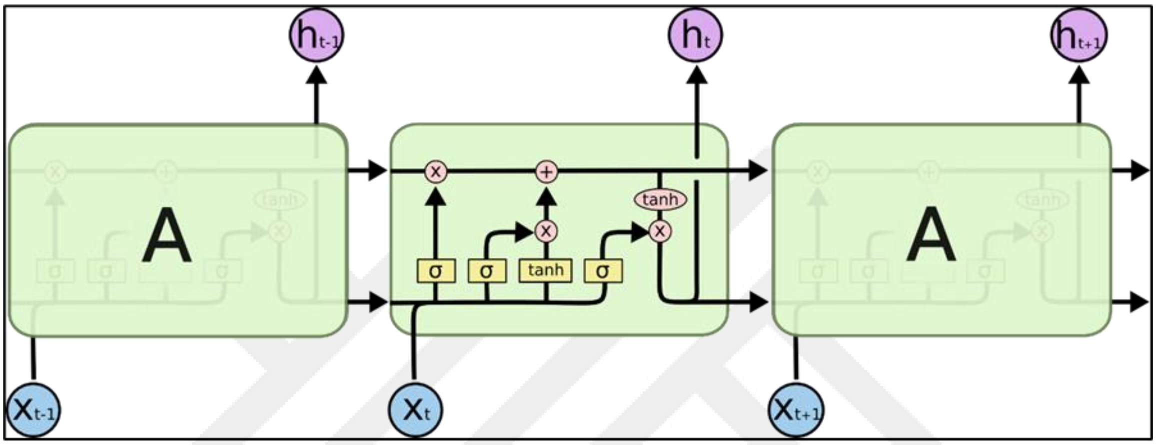


**Figure 3.9:** LSTM Structure [148].

In this case, the information may be valid without modification as shown in (Figure 3.10).

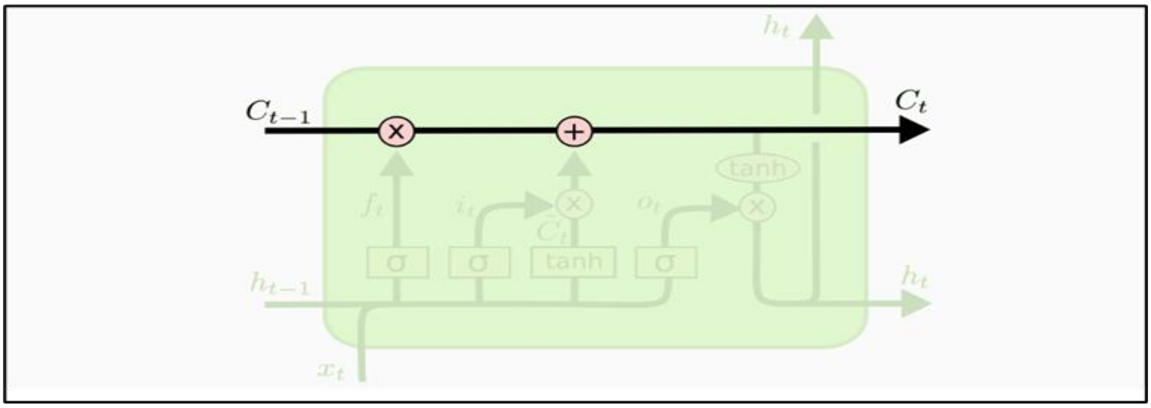


**Figure 3.10:** Without Modification [149].

The first stage is choosing whether the information is ignored or entered into the cell. This is performed by the "forget gate layer," a sigmoid layer that takes as input h_(t-1) and x_t and Each element output an output 0 or 1 in the cell state C_(t-1). A value of 1 indicates that the corresponding element should be entirely kept, while a value of 0 indicates that the element should be entirely discarded." As shown in (Figure 3.11).

$$f_t = \sigma(w_f . [h_{t-1}, x_t] + b_f) \tag{3.5}$$

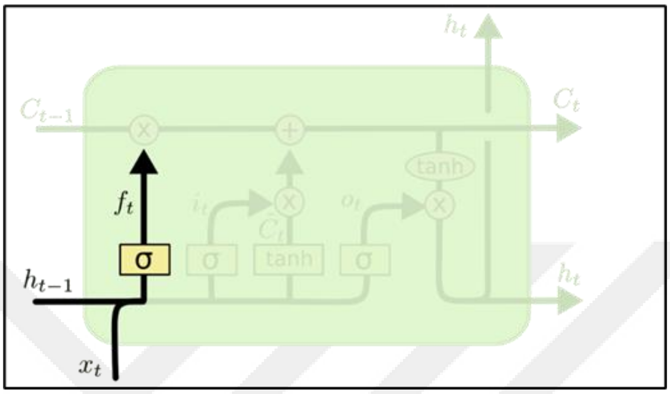


**Figure 3.11:** The Forgotten Door [149]

To determine which information to store in the cell state, the input gate layer, which is a sigmoid layer, is used to decide which values to update. Next, a tanh layer c reates a vector of new candidate values C̃_t that the state may incorporate. as shown in (Figure 3.12), these two will be combined to create an update to the state.

$$i_t = \sigma(w_i . [h_{t-1}, x_t] + b_i) \tag{3.6}$$

$$\tilde{C}_t = tanh\,(w_c . [h_{t-1}, x_t] + b_c) \tag{3.7}$$

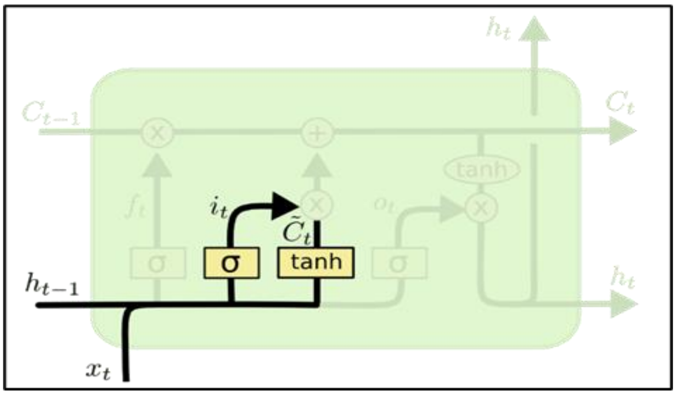


**Figure 3.12:** The Input Door [149]

And now the state of the old cell, C_(t-1), is updated to the new state C_t.Then we multiply the old case by ft, forgetting the one we decided to forget earlier, and then add i_t∗ C˜_t. Depending on what was decided to change from each state, the product that appeared in the new value is shown in (Figure 3.13).

$$C_t = f_t * c_{t-1} + i_t * \tilde{C}_t \tag{3.8}$$

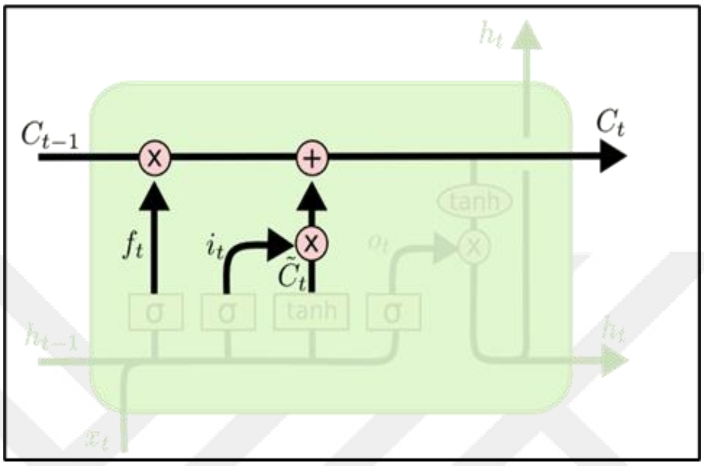


**Figure 3.13:** Update Cell Status [149]

Finally, In the output gate, the value to be output is determined based on the current cell state after passing through the sigmoid layer and the tanh layer control. Through filtering and output, the output is determined as shown in (Figure 3.14).

$$O_t = \sigma(W_o\,[h_{t-1}, x_t] + b_o) \tag{3.9}$$

$$h_t = o_t * tanh\,(C_t) \tag{3.10}$$

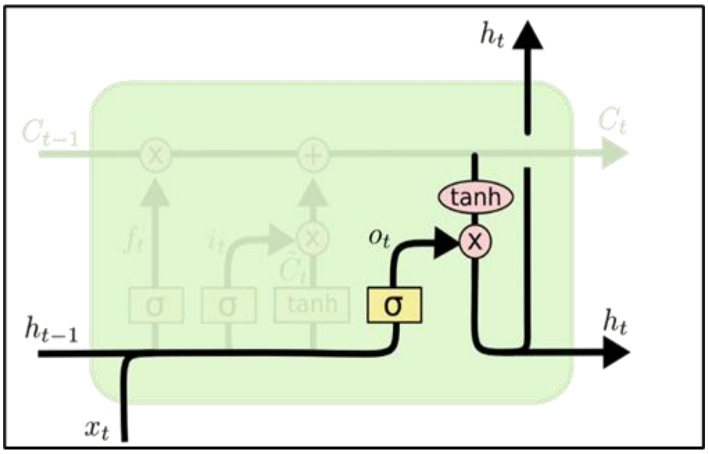


**Figure 3.14:** The Output Door [149].

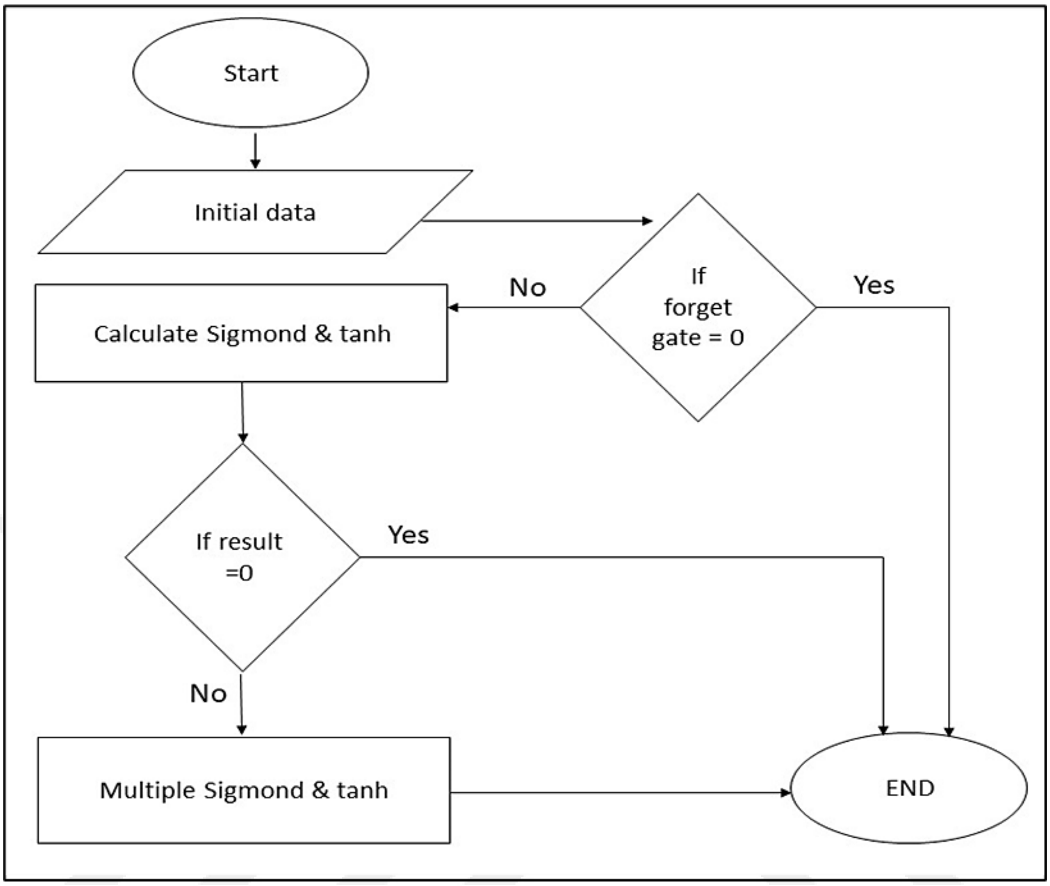


**Figure 3.15:** Flow Chart LSTM.

#### 3.3.4.1 LSTM model

This model is built using algorithms LSTM. The fundamental RNN structure serves as the foundation for the LSTM algorithm. The LSTM algorithm builds on the basic structure of RNNs by adding memory cells and gates that control the flow of information between memory cells and the hidden state, but it still uses the same building blocks of RNNs such as sigmoid activation Functions, multiplication, and addition. Based on this information, a predictive model was created using the LSTM algorithm, based on the basics of the RNN algorithm:

Imports the necessary libraries, including Numpy, matplotlib, pandas, TensorFlow, and the libraries for LSTM and Dense layers from TensorFlow. Keras, and libraries from sklearn for pre-processing and metrics calculation. Reads the dataset from a CSV file. The code is using the MinMaxScaler class from the scikit-learn library to normalize a dataset. The scaler is first initialized with the desired range for the feature values (in this case, between 0 and 1) and then fit to and transformed on the dataset. The code divides the dataset into training and test sets. Then, the train_size variable is defined as 67% of the length of the dataset, and the test_size variable is defined as the remaining length of the dataset. This is a common way to split the data into train and test sets for machine learning model training and evaluation. Then (LSTM) network is created using the Keras library to create I/O and forget gates. The model is trained with ten training iterations using training data and the "fit" function (epoch). In general, an epoch is a unit of measure for the number of times the machine learning algorithm has processed the entire training data set. And on it, make predictions about the training data "trainX" and the test data "testX" using the trained model's "predict" function. Finally, the error measures of the predictive model are calculated, and the results are printed into an excel (.csv) file.

# 4. RESULTS

This chapter presents discussions of the empirical, predictive results of models built using the proposed algorithms, and a comparison of which models are better using error measures.

## 4.1 EXPERIMENTAL SETUP

All necessary details regarding the experimental setup will be discussed in this section. includes information about the program used, as well as datasets.

### 4.1.1 Platforms

The models were trained on a computer with the specifications shown below, and the results were given on the same machine after being programmed on it. The device specifications are as follows:

a. Type: Laptop

b. Processor: Intel(R)Core (TM) i5-5300U-CPU @2.30GHz 2.29GHz.

c. Memory: 8.00 GB.

d. System Type: Windows 10, 64-bit OS.

### 4.1.2 Programming Language

Python was used in this research to create predictive models, as it is a high-level interpreted programming language known for its simplicity and readiness to read. It is widely used in various fields, such as web development, data analysis, and artificial intelligence. One of the main advantages of Python is the wide range of libraries available to it, which was used in programming models, including NumPy, Pandas, and Scikit-Learn, which provide strong tools for data processing and analysis. Visual Studio Code was used to write and correct Python code. This is because it provides many features that make Python's development more efficient, such as completing software instructions, correcting errors, and integrating with release control systems. In general, the combination of powerful Python libraries and the features of VISUAL Studio development make it a common choice for developers working on a variety of projects, from simple text programs to complex applications.

### 4.1.3 Data Discerption

In the third chapter-part (3.2), it was explained where the data came from and how long it was covered for the State of Turkey. The used data consists of (805) records and is divided into four classes (date, cases, recovery, and deaths) as shown in Table 4.1. To give a balanced data set and high-accuracy models with good results, work was done initially to remove undesirable data (empty fields), thus if we have missing values or blanks in the data set, it must be treated at the beginning. Then charts are made to understand that data, as shown in (Figure 4.1). It is important in knowing the facts and making the best decisions. It is called visualizing the data that will be used a lot in presenting the results. The data is then split into test data and training data before being utilized in the models, allowing the model to be trained using training data and tested using test data, which is a crucial component of data science.

**Table 4.1:** Sample of The Dataset.

| DATE | CASES | RECOVERY | DEATH |
|---|---|---|---|
| 25/03/2020 | 1526 | 477 | 15 |
| 26/03/2020 | 3253 | 442 | 16 |
| 22/03/2021 | 22216 | 19494 | 117 |
| 23/03/2021 | 26182 | 19201 | 138 |
| 10/04/2022 | 5609 | 7315 | 32 |
| 11/04/2022 | 6893 | 11207 | 28 |
| 31/05/2022 | 975 | 946 | 4 |

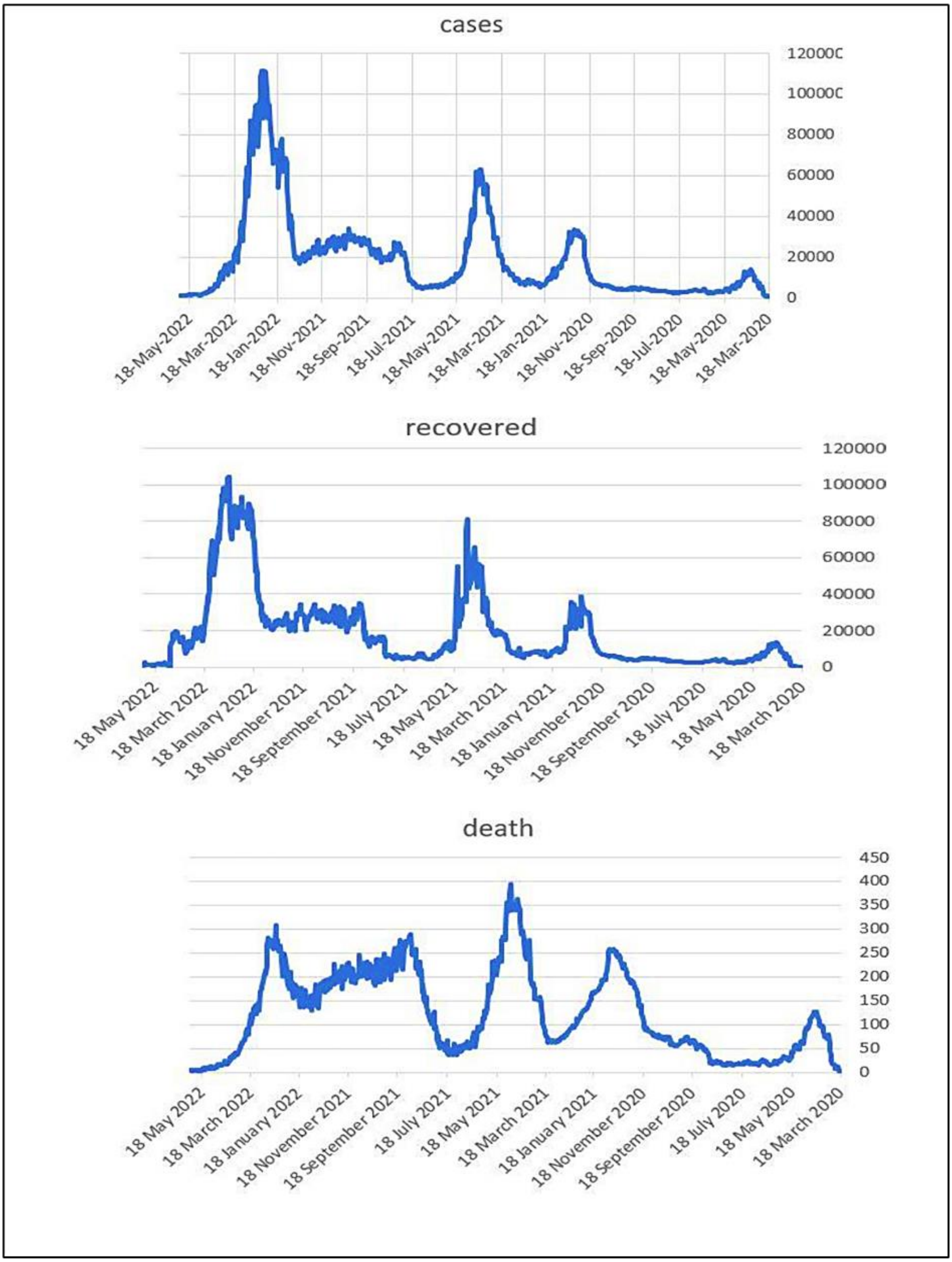


**Figure 4.1:** Data Visualization for a Dataset.

## 4.2 RESULT FOR EACH MODEL

a. Random Forest Model

The outcomes displayed in after building the prediction model utilizing the random forest technique (Figure 4.2). were obtained, so that predictions were made for the three cases (cases, death, and recovery) and the upcoming predictive year for the period from (1-1-2023) to (31-12-2023) monthly.

b. ARIMA Model

Predictions were made for the three instances (cases, death, and recovery) and the upcoming predictive year for the period from (1-1-2023) to (31-12-2023) monthly as a result of the data acquired after building the predictive model using ARIMA, shown in (Figure 4.3).

c. LSTM Model

As a consequence of the data received after developing the predictive model using LSTM, forecasts were created for the three instances (cases, death, and recovery) and the following prediction year for the period from (1-1-2023) to (31-12-2023 monthly, as shown in (Figure 4.4).

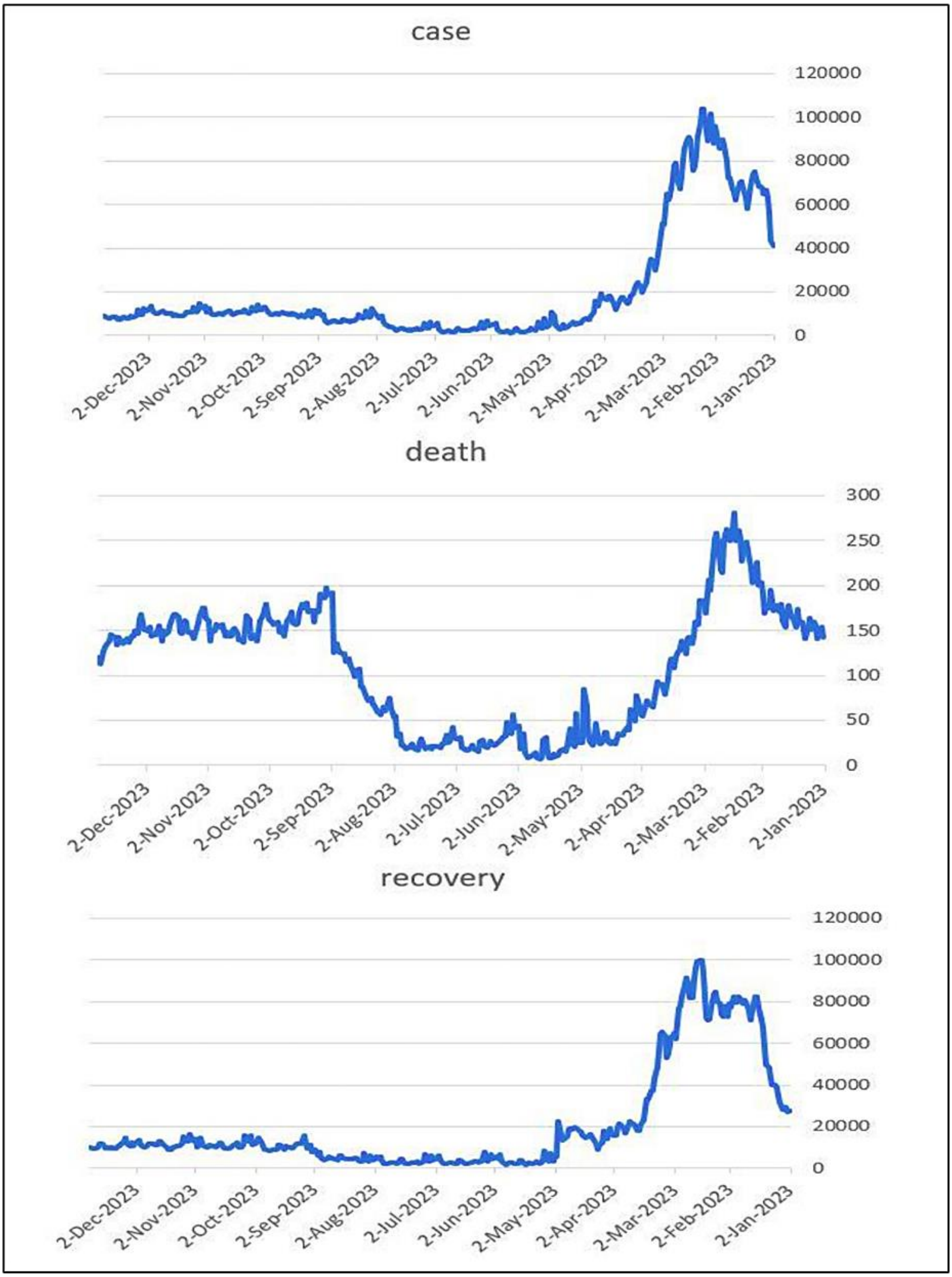


**Figure 4.2:** Result of RF Model.

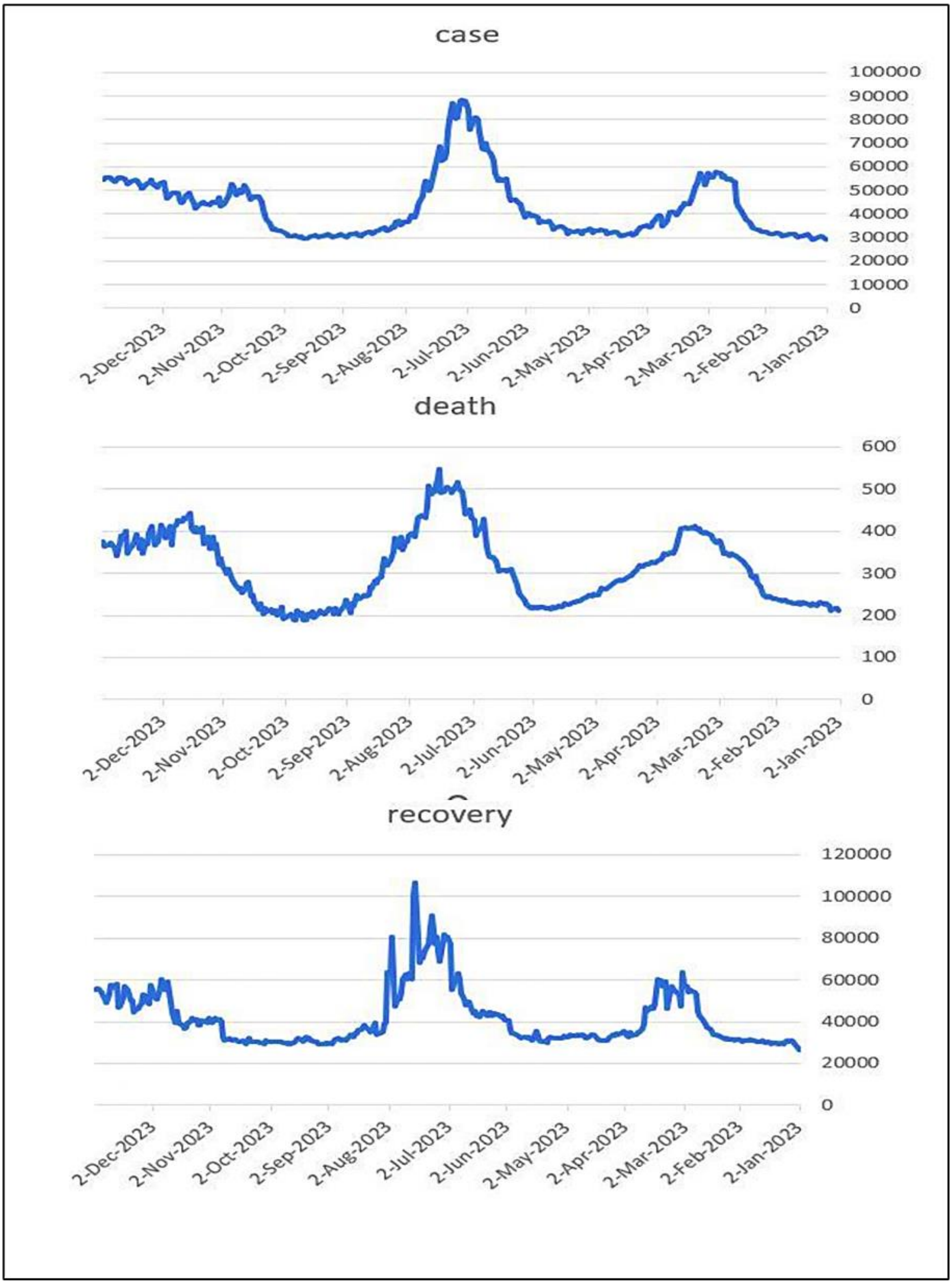


**Figure 4.3:** Result for ARIMA Model.

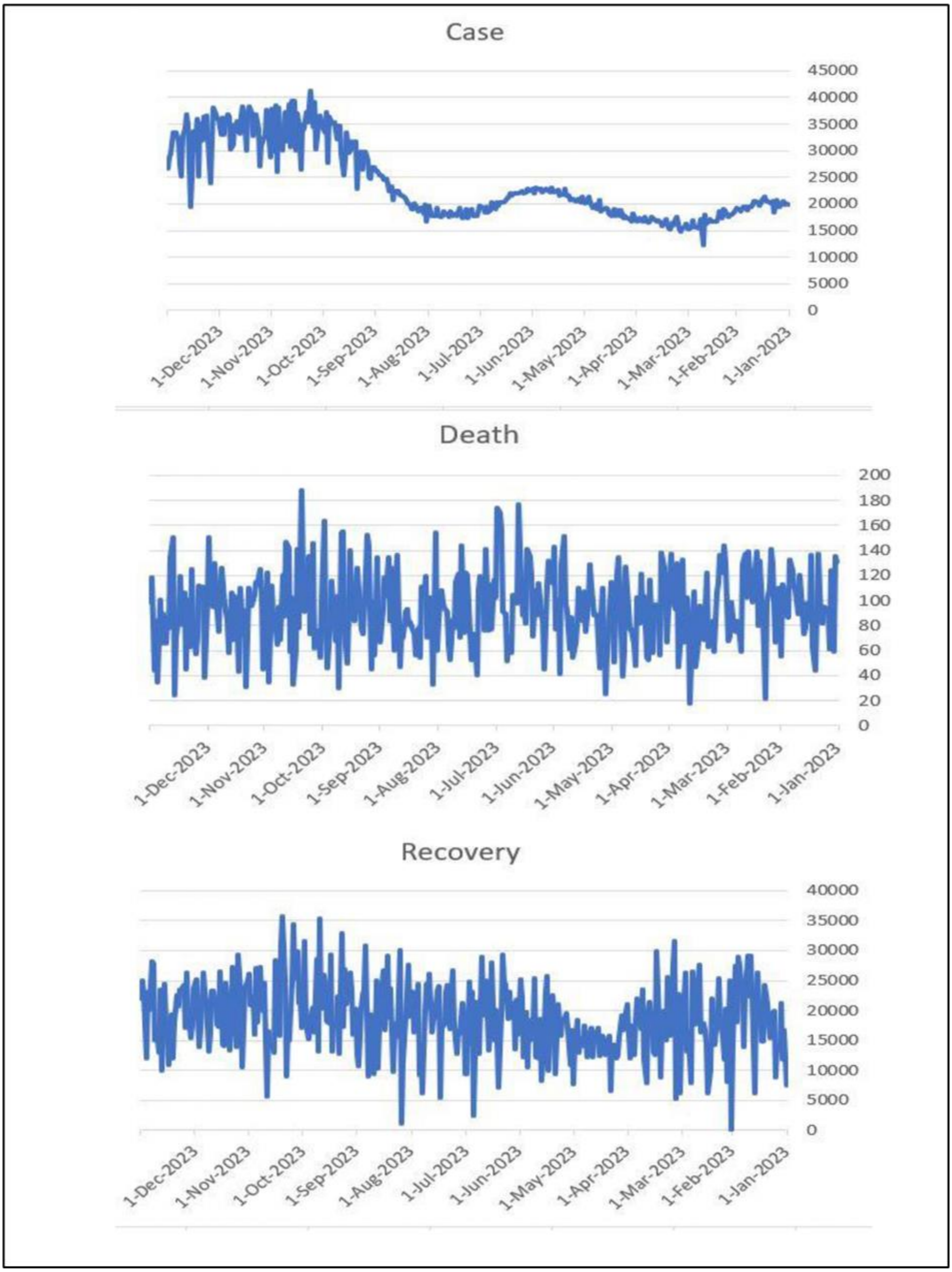


**Figure 4.4:** Result For The Lstm Model.

### 4.3 PERFORMANCE MEASURES

The models were tested using time by calculating (the training time, the time to create the model, and the time to obtain the predictive results for each model), as well as using error measures, as these measures were used in each algorithm depending on the model (case), using data from the same sample For the examination process by comparing the actual data with the expected data for a certain period and obtaining the results of the error measures where the model with the lowest results is the best and as shown in Table 4.2 below, so that the number symbolized in red is the lowest value for that model and it is the best.

**Table 4.2:** Performance Measures for Each Model.

| Error Measures | MODEL (RF) | MODEL (ARIMA) | MODEL (LSTM) |
|---|---|---|---|
| MAE | 3227.053 | 592.647 | 2778.514 |
| RMSE | 4946.609 | 1007.816 | 4724.22 |
| MAPE | 35.942 | 0.084 | 9.117 |
| MASE | 0.157 | 0.470 | 1.069 |
| Time | 2.00 s | 0.14 s | 0.50 s |

# 5. CONCLUSION AND FUTURE STUDIES

In this study's chapter, what has been concluded through the results obtained using intelligent models will be reviewed, and then future recommendations and suggestions after this study will be mentioned.

## 5.1 CONCLUSIONS

This thesis' objective is to offer direct insight into the time series of the Corona pandemic in the Republic of Turkey's prediction process utilizing artificial intelligence algorithms and the prediction method. By employing algorithms (RF, ARIMA, RNN, and LSTM) to build prediction models for this study, what was discussed in the theoretical chapters was put into practice, and the following outcomes were compiled at the end:

a. Artificial intelligence in the health field plays an important role in detecting COVID-19 in most countries, when predictive models that contain the largest amount of accurate health data are trained for the Corona pandemic, the results are more accurate, however, it is important to remember that artificial intelligence cannot take the position of a health expert. Instead, it enhances their job in that field and helps them increase diagnosis accuracy in a shorter amount of time, which reduces their workload.
b. Whenever the data used in training is large and far-reaching, the model gives good results and is closer to the truth, and has lower percentages in terms of error rate. Therefore, it is concluded that the performance of predictive models depends on the features of the data set used.
c. If the prediction is made in the long term, it can sometimes give results that are relatively far from the truth, so in this research, the prediction was used for a maximum period of one year, and the results were Near to actual cases.
d. By applying the three predictive models to the data used in this research, it turns out that the RF model is the worst among the rest of the models, due to the high proportions of error measures and execution time. As for the LSTM model, after calculating the error measures and execution time, the results were less compared to the RF model, and therefore it is somewhat better. As for the Arima model, compared to the other models that were utilized in the research, it is the best. After

calculating the error measures of the model and calculating the execution time, the results were very few, and this indicates that it is the best, See Table 4.2 in Chapter Four.

## 5.2 FUTURE STUDIES

After presenting the results drawn from this research, future proposals that may be useful for the health sector will be presented:

a. These models can be extended to apply predictions to other diseases, which will enhance the quality of the healthcare system.
b. It is possible for researchers, after this study, to use more recent data, relying on modern website platforms, to keep pace with their current time, and to make predictions useful for the distant future.
c. It is possible to apply the predictive model to more than one different country around the world, and the use of field-collected data can give better results.

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