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The Impacts of Various Machine Learning Methods for Effective Pandemic Management: A Review

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Abstract

The unexpected outbreak of COVID19 affected the world deeply in terms of social as well as economical. It's been almost two years passed still the pandemic is uncontrollable. Most underdeveloped countries fail to respond this critical situation due to a lack of resources as well as improper health care system. This pandemic had also raised the questions about the preparation of the health care system for any other outbreak. There have been several suggestions to manage any type of pandemic properly and effetely in future by using the new advancement medical science and specially using of technologies like artificial intelligence (AI) and machine learning (ML). This paper will review some state-of-the-art artificial intelligence (AI) and machine learning (ML) tools for pandemic management. As we know that ML models have handled the multidimensional, large volume of real-time data related to pandemic management. These models are very well suited for prediction, classification, and recognition problems. ML models now plays a key role in pandemic management, such as pandemic prediction, people surveillance, risk management, medical diagnosis, and screening. This article presents an overview of pandemics, reviewing some ML models and their application in pandemic management. The last section discusses the challenges and future research.

Keywords: *Pandemic Management, Machine Learning (ML) Applications, COVID19 Predication, Corona Virus, Health Care.*

Introduction

A pandemic is a rapid spread of a disease worldwide. There is a list of diseases that spread across the globe, damaging humanity. Among these deadliest epidemics were the American plague (16th century), yellow fever in Philadelphia (1794), swine flu (2009-2010), Ebola virus (2014-2016) and the most recent COVID 19 (2019-Present). The deadliest was the black death causing an estimation of 50 million death all around the world. This disease spread all over the world, including Asia, Africa, and Europe.

Similarly, the COVID19 pandemic started from Wuhan, a city of China in December 2019 spread worldwide within a short span. This epidemic affected over 250 million people worldwide, causing over 50 million deaths. This pandemic not only effete human life but also destroys the world ecumenically. According to Statista.com (Szmigiera, 2021) the world lost about 3.4 trillion US dollars in worldwide GDP, millions of people lost their jobs. The global hunger index also highlighted that the hunger index also increased significantly due to COVID19. Despite COVID, several other diseases are causing severe issues to human life, including Dengue fever, the influenza flu, etc. A disease turns into an epidemic because it can spread itself from person to person. The study on epidemic patterns and spread ratio helps us find the pattern of their transfer to restrict it from being scattered. It also allows us to improve the survival ratio, decrease death date, and improve the survival rate. The informative data from these practices can be shared on social networking sites to counter the epidemic. This process is essential for health care to fight against these deadliest epidemics to minimize the precious lives and economic losses. The problem here is that the virus spread very vastly, and to stop its transfer and mitigate its effects, we need real-time data for processing. Also, a proposed solution can process the real-time data in no time and produce quick results. But most of the recent techniques are either too complex or unable to handle data on a large scale. Therefore, the need of new and emerging approaches that can handle all the explained problems as well as capable enough to predict the outcome more accurately.

A. Machine Learning (ML)

Machine Learning (ML) is one most emerging and powerful technologies now a day. ML is the computer's skill to learn without human interference. The main idea of ML is to learn from input data to predict the value of testing data.

$$y = f(x) \qquad (1)$$

Where 'y' is the output of prediction function 'f' applied to input 'x' (Sahli, 2020). As ML is growing, machines are becoming smarter and smarter. Therefore, they are surpassing humans and providing better assistance in many domains. So, we can say that ML is the future of humanity (Panch, 2018). Machine Learning is further divided into supervised, unsupervised, semi-supervised reinforcement learning (Alom, 2018)

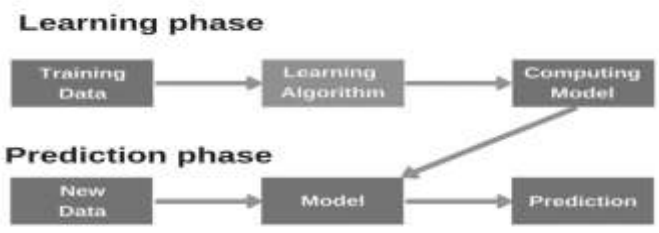

Figure 1: A machine learning model predication process

Literature Review

ML has emerged as a potential candidate for future predication and has increasingly used in various domains (Contributors., 2020). The ML models are based on artificial intelligence and used the data to make future predications. ML models can be applied in low human supervision and can work in unpredictable environment. The ML models have the following advantages in pandemic management as compared to other technologies.

1) The ML models can easily process large volume of data and predicts the trends. The models are already applied in traffic predication, stock trends and predication and video surveillance etc.
2) The ML models are also very accurate in fake news detection. Therefore, these models are very useful to counter the fake news about the epidemic.
3) As the performance of ML models increases when the data increase. The pandemic predication the models predicts accurately with large data.

In this paper we present a basic tutorial of some ML models and the applications of these models for pandemic management. This paper is structured as follows. Section II presents few machine learning models. Section III reviews the application of ML models in different pandemic management scenario. Section IV highlights the application of ML models in tabular form. Challenges and future directions are discussed in section V. At last, the section VI discussed the conclusion of the article.

Machine Learning Models

In this section we will discuss some of ML models that can be used for pandemic management. Table 1 presents a brief summary of machine learning methods used for pandemic prediction. The table shows that researchers have used several different factors to detect the onset of pandemics. The accuracy of these methods shows that in presence of relevant data, machine learning methods can effectively predict such pandemics. Some of these methods are discussed in the sections below.

A. K- Nearest Neighbours (KNN)

The KNN is very simple ML model mostly used for classification purposes. The structure of a simple KNN model is shown in figure 2. The model is a lazy learner it takes time to learn for input data. (Ginantra N. L., 2020) used the KNN model for the detection of Influenza disease in the patients.

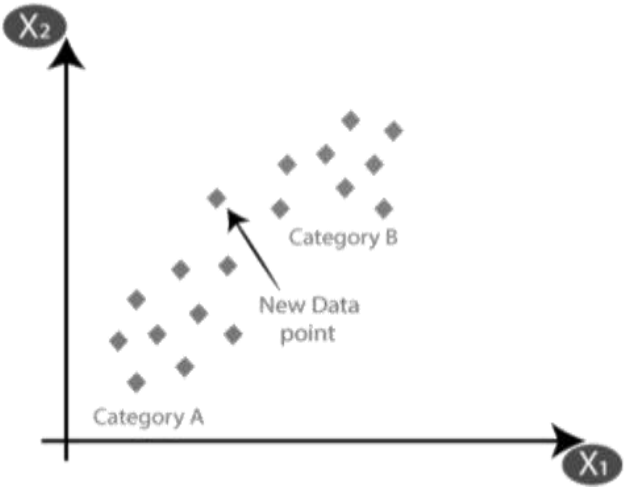

Figure 2: Shows the functionality of KNN models

B. Support Vector Machine (SVM)

The SVM is another very famous machine learning tool used for both classification and regression problems. The SVM works on the idea of hyperplane for classification of data points. The figure 3 shows the structure of SVM model. (Yin R. T., 2018) used the SVM model for the detection of ISPA in people.

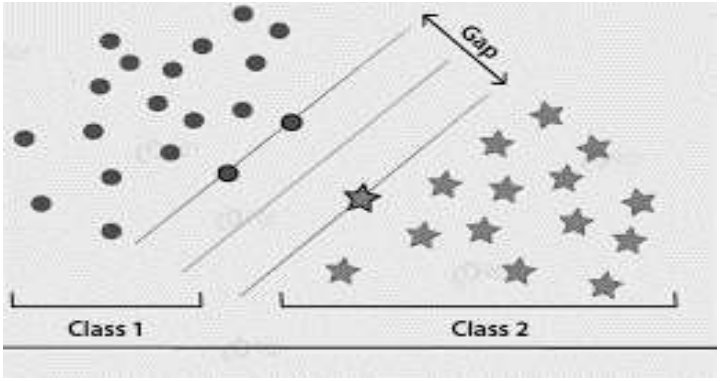

Figure 3: A simple SVM model for data classification

C. Random Forest (RF)

Random Forest is another very famous and simple ML technique used for classification and regression problems. The RF consists of many decisions tree. The model calculates the predication by combining the average of all the outcome of different decision tree. The RF is very useful for handling the missing data and also more accurate from decision tree. The figure 4 shows the process of random forest model.

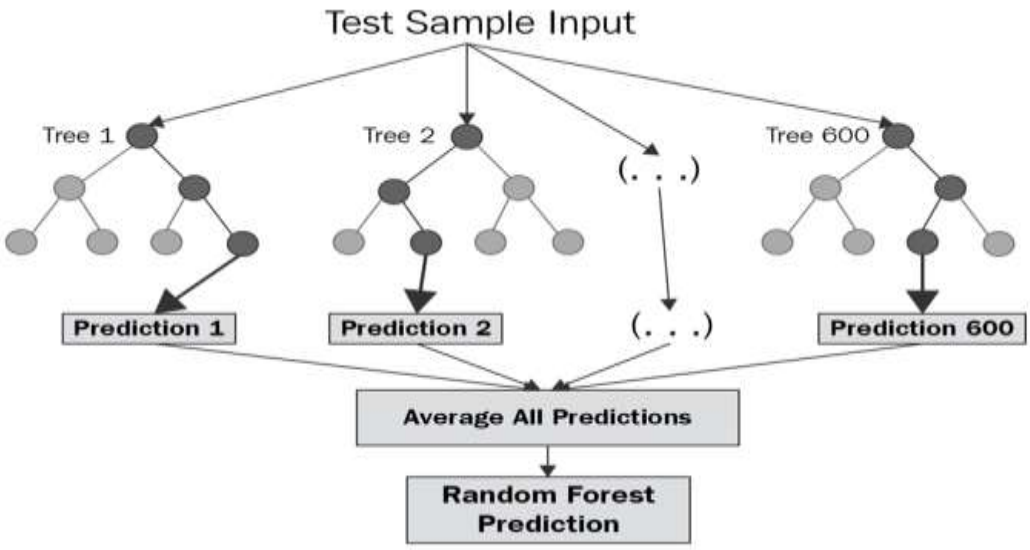

Figure 4 : structure of random forest model

D. Artificial Neural Network (ANN) and Deep Neural Network (DNN)

ANN are the multi layered neural network that are designed just like the human brain in order to solve complex real-life problems. There are several network models that are specially designed for specific purposes. Artificial Neural Network (ANN), Convolution Neural Network (CNN), and Recurrent Neural

Network (RNN) are some of the very famous neural networks. (Tamang, 2020) forecast the COVID19 cases using the artificial neural network. (Uhlig, 2020) also used the ANN model for model projection of COVID19 pandemic.

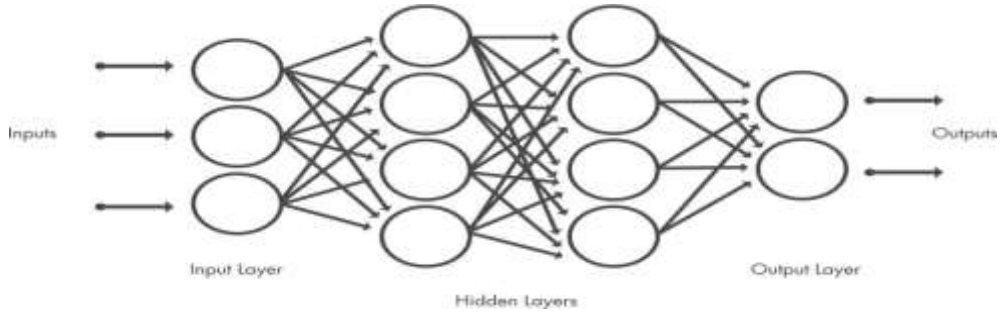

Figure 5: The structure of CNN model

Applications of ML in Pandemic Management

In recent years, computer science and artificial intelligence advancements made it possible for humans to solve different data processing problems using various data analysis and visualization techniques. Also, the machine learning models have been used to solve complex real-life problems of computer vision, image recognition, pattern recognition etc. (Contributors, 2020). The machine learning model can be valuable to fight against these epidemics. This technology helps in the prediction, prevention, and mitigation of different diseases before they spread worldwide. Before going into the other details of machine learning models already used for these processes, we first look at different machine learning models that are successful in solving different kinds of problems. As we know that ML has been used in pandemic prediction, prevention, and mitigation process. In this section, we will describe some of the machine learning models used in the pandemic management process.

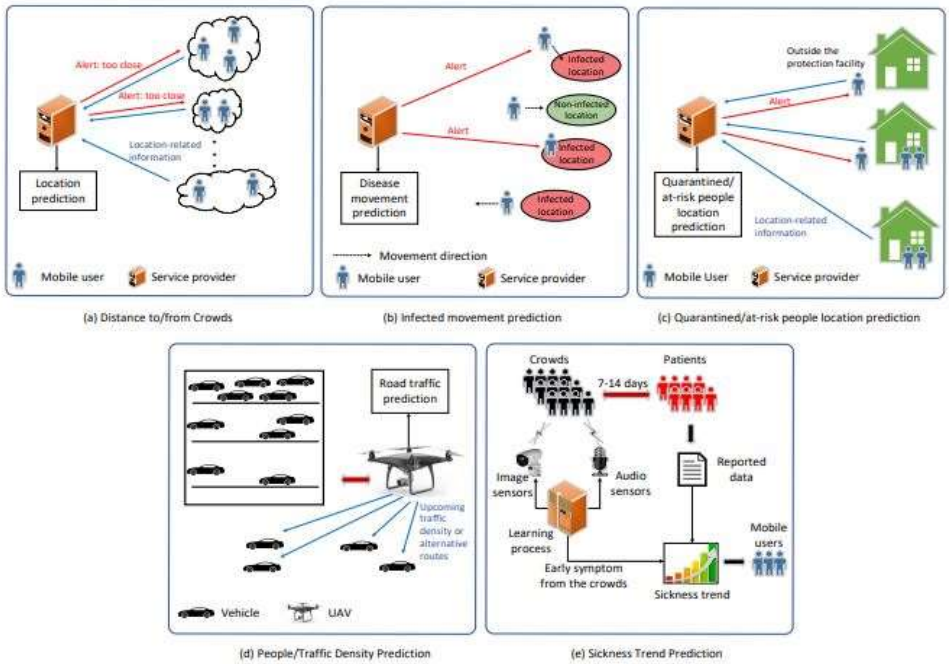

Figure 6: The different applications of AI and ML models for pandemic management (Nguyen, 2020)

A. Prediction of Pandemic

To prevent the outbreak of a pandemic, an early diagnosis is required. Therefore, several methods have been used for the early prediction of different diseases. The (Ginantra N. L., 2020) used different machine learning models to predict patient's Acute Respiratory Infections (ISPA). For this purpose, the author used the fever, headache, Flu, Cold, Cough and Blurry view symptoms among the patient. The performance of different ml models was measured in terms of sensitivity, specificity, and accuracy. The results indicated that SVM outperforms the other ml model, including KNN, Naive Bayes and neural networks. The SVM achieved 100% sensitivity, specificity and 0.98% accuracy for the prediction of infection among the patients. (Yin R. T., 2018) used the machine learning model to predict the antigenic variant of influenza H1N1. The model used three different feature engineering methods: residue-based, regional-based, and epitope region-based, to verify the robustness of the model. The accuracy, specificity and sensitivity were tested for different machine learning models. The experiment was conducted on linear regression, support vector machine, neural network and KNN. The stacking model helped in the predication of antigenic variants of influenza and overcome the challenge of mutation variants.

Lopez-Rincon (2020) used the deep convolution neural network for the identification of SARS-CoV2 and classifying its different variants. The author used secular methods like RT-PCR (quantitative real-time), and for this purpose, The experiment was conducted on Novel Corona Virus Resource (2019nCoVR) for the identification process. The proposed scheme achieved 98.75% of accuracy with a specificity of 0.993 and 1.00 of sensitivity. (Pinter, 2020) used a hybrid machine learning approach to predict the COVID19 in Hungary. They used the adaptive network-based fuzzy interface system (ANFIS) and multi layered perceptron imperialist competitive algorithm for this process. The model used real data to predict the time series of individuals and the death rate. For the record, the model predicted that the morality rate would drop in May, and it occurred in late May. The model had maintained its accuracy until a significant interruption occurred.

There are several efforts have been made to predict the outbreak of dengue fever using machine learning models. (Salim, 2021) used different machine learning support vector machines (SVM) to identify outbreaks of dengue fever in different districts of Malaysia. It used the data from 2013 to 2017 to predict the next outbreak of fever. The factors included temperature, wind speed, rainfall, and humidity were used as the prediction factors. The model achieved an accuracy of over 70% and a specificity of 95%. These promising results show that machine learning models can be used to predict the outbreak of a disease. (Iqbal, 2019) also used different machine learning models to forecast the outbreak of dengue. It used the fever, headache, white blood cell ratio, abdominal pain, and other predication factors: the logistic regression, decision tree, naïve Bayes, KNN and artificial neural network. The models achieved very good accuracy for the prediction of dengue. Logit Boost achieved an accuracy of 92% and specificity of 94%. Several other methods like CNN and GAN need to be implemented to achieve more accuracy for the prediction of the outbreak.

B. Prevention and Mitigation

Despite predicting a pandemic outbreak, machine learning also plays a key role when an outbreak occurs. The COVID19 is a major outbreak in this century that cause large scale distractions all over the world. During the pandemic, various stages like surveillance, medical diagnosis, screening, and risk predication are the key factors that need to be addressed. (Chamola, 2020) also highlighted the role of IoT, 5G and artificial intelligence to prevent and lower the effects of an outbreak.

C. Disease Surveillance

During a pandemic, it is important to monitor and forecast the disease outbreak. For this purpose, a Toronto health company BlueDot successfully reported the outbreak of COVID19 before the WHO noticed it. It is

an AI-based surveillance model that uses several machine learning and natural language processing models for the purpose (Hollister, 2020). Also, several other organizations used AI tools for the smart surveillance of the pandemic. Metabiota (Metabiota, 2017) had developed a pandemic tracking tool that forecasted the spread of disease. With tracking, also provided up-to-date information and news about the outbreak. As time passes, a large volume of data regarding the virus has been gathered that could help the AI and machine learning model predict the potential cause. This will help to develop the vaccine and prevention measures.

D. Risk Prediction

Another strong implementation of AI and ML tools are risk management after the epidemic occurs. (Fighting COVID-19 with Data Science, 2020) classified the risk management into three phases.

1. Risk predication of people getting infected.
2. Risk prediction of the infected people to develop severe symptoms.
3. Risk prediction of the specific treatment.

Also, several authors used AI and machine learning models for risk prediction. (DeCaprio, 2020) used the logistic regression model to build a vulnerability index for every person sensitivity regarding the virus. These risk factors help the medical staff to better prepare for the consequences.

E. Medical Diagnosis and Screening

Currently, the screening of the patients at ports and checkpoints is done through temperature scanners by measuring the person's temperature. AI model can also help in screening by combining the temperature information and other user data to find the probability of infection. (Beck, 2020) used the deep learning model to identify the COVID patients by using the X-ray image of the patient.

F. Drug Development

One of the major challenges during the COVID pandemic is the lack of existing research and treatment for the virus. Machine learning methods are very useful for the speeding up drug development process (Rees, 2020). During the Ebola epidemic (Ekins, 2015) used machine learning tools including SVM, random forest, and Bayesian to speed up constructing a molecular inhibitor against the virus. (Zhang, 2020) build a Dense Fully Convolution Neural Network (DFCNN) to classify protein-ligand interaction with high accuracy. This suggested that machine learning not only help in drug preparation but also suggests a possible treatment for the patients.

G. Social Distancing

As the COVID virus has spread in 210 countries within only nine-month times causing large scale devastation all around the world. (Chong, 2020) highlighted the role of different machine learning algorithms in different phases of epidemic. As the COVID virus spreads through human interaction, social distancing has become an important tool to stop this spread. (Challita, 2019) combined the UAV data and current and convolution neural network to predict the traffic density on the roads. This information can be provided to users to avoid the crowded area. (Johnson Jr) used the camera and portable radar data to train a neural network. This NN was trained to identify objects, vehicles, and human beings. The NN allowed the user to maintain the social distancing and kept a record of users that violated the social distancing. (Al Hossain, 2020) developed a model using machine learning methods that notify the users about the infected people around them. The model was trained on influenza symptoms, and it detected the infected people. It analyzed the cough sound of different people and the total people around the area. The random forest

model was used for the prediction that achieved an accuracy of 95%. The model is also very useful for informing people about the infected people during the pandemic.

Table 1 : The application of ML tools for pandemic prediction

S.No	Reference	Targeted issue	Target disease	Technology used	ML used	Factors Involved	Performance Variables.	Country
01	(Ginantra N. L., 2020)	Predication	Prediction of antigenic variants of influenza virus.	Support Vector Machine (SVM), KNN, Neural Network	Yes	Fever, Headache, Flu, Red Rash, Cough, Sore Throat.	Accuracy=97%, Sensitivity= 100%, Specificity=100%	WHO
02	(Prakash, 2020)	Predication	Predication of SARS-CoV-2	Random Forest Regression, Random Forest, SVM, KNN	Yes	Tiredness, Fever, Dry Cough, Headache, Severe Pain, Sore Throat and Lack of taste and smell.	Accuracy =96%	India
03	(Rustam, 2020)	Forecasting	Future forecasting of COVID19	Linear Regression, LASSO, and SVM	Yes	Death rate, Recovery, Confirmed Cases, Location, and Region.	$R^2 = 0.96$, MAE= 723.11 and RMSE= 916.64	South Korea
04	(Kumar, 2020)	Predication	Predication of COVID19	Logistic Regression, Decision Tree, Random Forest, XGB Classifier, and Random Forest	Yes	X-ray images of the patient of COVID19 victims.	Accuracy=98%, Sensitivity= 97%, Specificity= 98%	India
05	(Nejad, 2021)	Predication	Predication of dengue outbreak	Bayes Net, Decision Tree, Naïve Bayes, Support Vector Machine	Yes	Temperature, Rain, Rainfall, Humidity,	Accuracy=92.3%	Malaysia
06	(Chovatiya, 2019)	Predication	Predication of Malaria	LSTM, RNN	Yes	Weather, Humidity, Rainfall, Air Quality, and Pressure	RSME=0.061	India
07	(Rajput, 2021)	Predication	Predication of Ebola Virus	SVM,RF, and ANN	Yes		MAE=0.33 RMSE=0.47 PCC=0.98	India
08	(Delafiori, 2021)	Medical Diagnosis	Medical Diagnosis of COVID19	Gradient Tree Boosting (GTB),	Yes	Age, Sex, Hospitalization, Oxygen Level, Diabetes,	Accuracy=95.5 Precision=95.3 Sensitivity=95.9 Specificity=95.2	Brazil

				ADA		Hypertension, Chronic Hepatic Disease, and respiratory disease		
09	(Khuzani, 2021)	COVID19 Medical Diagnosis	Automated Diagnosis of COVID19 patients	CNN	yes	CT Scan and X-Ray images of the patients.	Precision=100% Sensitivity=100% F-Score=0.98	USA
10	(Zawbaa, 2020)	Surveillance	Social Distancing for the COVID19 prevention.	Multi-Layer Perception (MLP)	Yes	Age, Temperature, BCG Treatment, and Malaria Treatment	RMSE=318.29	Egypt
11	(Soures, 2020)	Social Distancing	Social Distancing Measure for COVID19 virus Spared.	LSTM and RNN	Yes	Incubation Period, Shedding, Initial Infected Cases, and Hospital Bed	Mobility ratio	USA
12	(Nadikattu, 2020)	Surveillance	Surveillance for COVID19 outbreak.	ML models	Yes	Fever, Cough, Covering Mouth, Short of Breath.	$R^2 = 0.95$	USA
13	(Gong, 2020)	Risk Management	Risk Management for COVID19	LASSO, regression, RF, SVM	Yes	RNA detection, Fever, respiratory infection, white blood cells count, lymphocyte counts	AUC= 0.912 Sensitivity=85.71 Specificity= 87.58%	China

Challenges and Issues

Now a days, ML and AI are considered to be advanced technologies, but still there are various challenges that need to be addressed to manage the pandemic situation in a proper way. In this section, we will highlight the major challenges while adopting these models in pandemic management.

A. Input data Issues

As the real-time data provided to the system for training that may be wrong or incomplete. Thus, the model will also produce incorrect results. Also, there is no method to verify the authenticity of the input data. Therefore, the model predicts the results based on the trends and patterns in data. Sometimes the trend may not be wrong. So, the ML model will predicate the results that may be incorrect. So, the incorrect and incomplete input data is a major challenge for adopting the ML models for pandemic management.

B. Hunger for Data

Most ML models, including CNN and SVM, required a very large amount of training to produce accurate results. As the data for COVID19 is not large enough, it is very difficult to use CNN in this situation.

C. User Privacy

While applying the ML model it should be considered that the model must not violate the user privacy. Some of the model used for surveillance and tracking may violate the user privacy, therefore some mitigation policies are required to tackle this issue.

D. Outliers and noisy input data

Most of the ML models are sensitive to noisy data and outliers so, the noise and outliers existed in the data is another major challenge while apply the ML models in real time scenarios. Although the ML are very difficult while applying in real environment but still the model possesses the power to performs efficiently. The AI and ML technology have made a stunning advancement in natural language processing and deep learning. Such development can improve the potential of ML models in managing the pandemic.

Future Research Directions

Despite several challenges and issues described in above section still the ML model are enhancing the ability in many aspects of pandemic management. There are certain directions that need to be considered to achieve the maximum output from these models.

1. Many Machine Learning models works efficiently with high resolution images, while in real- time data high resolution images are not available. So, either high resolution image must be provided, or the model need to be mature or trained enough to achieve accurate results using low resolution images.
2. The preprocessing or training of the should be improved in order to deploy in real time scenario.
3. There are several measures used for the performance of these models including accuracy, sensitivity, Area Under Curve, Precision and Recall, so there should be a standard unit for the measurement of performance of these models.

Conclusion

In the last two years, pandemic management has become a major issue all around the world. The ML model has been used in many domains to solve various complex problems. This article presented a comprehensive survey of the applications of ML and AI models for pandemic prediction. It first explained the details of machine learning models. Then we highlighted the various stages of pandemic management where ML algorithms can be used. The next phase is the application of ML models in pandemics like COVID19, dengue, affluenza, and others. At last, we pointed some key challenges for the application of these models.

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