# A Survey of Machine Learning Technologies for COVID-19 Pandemic

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***Abstract*—Intelligent technologies including machine learning and artificial intelligence are playing significant roles in human's battle against COVID-19 pandemic. Machine learning enables the machine to learn and improve on its own without being programmed in detail. Machine learning has now penetrated into many fields to help fight the epidemic. However, a specific and representative review of the contributions of machine learning is currently lacking. The purpose of this paper is to summarize several machine learning applications against COVID-19 including: i) predicting confirmed cases and trend, ii) classifying and diagnosing using ML-based images, and iii) managing medical resources. A database related to machine learning Technologies for COVID-19 is created. Moreover, a concise review is finished on the collected information by evaluating the different uses of machine learning against COVID-19. We also assemble researches in the present COVID-19 literature focused on ML-based methods in order to demonstrate a profound insight into COVID-19 related topics. Our discoveries emphasize crucial variables and available COVID-19 resources that facilitate clinical and translational research.**

***Keywords—Machine Learning, COVID-19, prediction, diagnosis, medical resources management***

## I. INTRODUCTION

Since the appearance of the first confirmed patient on December 8, 2019, humans have begun to fight against the COVID-19 virus. As of 7 September 2021, the virus has spread in more than two hundred countries, causing 221,134,742 confirmed cases and 4,574,089 deaths. In order to count and report the latest confirmed cases, reduce people's exposure to the virus, control a large number of medical resources, and research on the future development trend of the virus and the virus itself, medical workers and researchers have used machine learning to help solve these problems. Some analyses aimed at computational epidemiology, disease progression and early detection and diagnosis have been summarized and proposed. [1] Recent studies have shown that for medical staff, machine learning (ML) is a powerful and efficient tool because it can promote scale, increase processing power, and demonstrate human capabilities in medical fields [2]. Also, researchers can use ML models to estimate the mortality of COVID-19 patients. This paper provides a comprehensive review of ML techniques against COVID-19 pandemic.

Many experts have taken deep research in ML and COVID-19 since the epidemic happened. Fast diagnosis and screening process are cost-effective, help suppress the spread of COVID-19, and speed up the related diagnosis. What's more, Ye conducted a study that identified and evaluated medical technologies including cloud computing, mobile healthcare, big data, and artificial intelligence, against the pandemic.

The structure of this article is as follows: In Section 1, we have listed the history of the development of machine learning and the previous research in machine learning and COVID-19. In Section 2, we will summarize three applications of existing ML-based models and technologies during COVID-19 pandemic: The first application is ML-based technology in predicting confirmed cases and trend, including predicting confirmed cases and death rate, and evaluating the time incidence of COVID-19; The second application is ML-based images promoting classification and diagnosis, including chest X-ray and CT image analysis; The last application is ML-based technology in managing medical resources, including predicting the choice of drugs and the need of ventilation, designing the structure of vaccines, calculating the need of ICU transfers, and managing the use of operating rooms. The detailed descriptions of these three parts will be discussed in Section 3, 4 and 5. Finally, in Section 6, we intend to draw some conclusions and present the future research. We hope that by summarizing and highlighting existing machine learning technologies, this paper can facilitate clinical and translational research. So that human will win this pandemic battle earlier.

## II. APPLICATIONS OF MACHINE LEARNING TECHNOLOGY DURING COVID-19 PANDEMIC

In Table 1 above, we have made a list of all the applications that will be discussed in our articles, that is predicting confirmed cases and trend, using ML-based images to classify and diagnose and managing medical resources. For each applications, we give some more detailed descriptions, including the specific methods and technologies that were used

in existing papers. The more detailed discussions will be given in Section 3, 4 and 5.

TABLE I. APPLICATIONS OF MACHINE LEARNING TECHNOLOGY DURING COVID-19 PANDEMIC

| Applications | Descriptions |
|---|---|
| predicting confirmed cases and trend | ● Predict the number of confirmed cases<br>● Predict the death rate of COVID-19<br>● Evaluate the time incidence of COVID-19 |
| classification and diagnosis using ML-based images | ● Chest X-ray image analysis<br>● CT image analysis |
| medical resources management | ● Predict the best drugs<br>● Design the structure of vaccines<br>● Predict the need of ventilation<br>● Evaluate the need of ICU transfers<br>● Manage the use of operating rooms |

## III. ML TECHNOLOGY IN PREDICTING CONFIRMED CASES AND TREND

### *A. Description of ML Technology in Predicting Confirmed Cases and Trend*

We have listed all the ML-based prediction models in Table 2 and the following articles will give a detailed introduction to them.

TABLE II. ML APPLICATIONS: PREDICTION FOR CONFIRMED CASES AND TREND FOR COVID-19 PANDEMIC

| Categories | Publications | Methods | Innovative | Traditional Model |
|---|---|---|---|---|
| Tentative predictions of the epidemic peak for Russia, Brazil, India and Bangladesh | [3] | A newly developed algorithm based on Trust-region-reflective(TRR) algorithm. | √ | |
| Predicting the number of confirmed cases and the death rate of COVID-19 in the world. | [4] | Time series model. | | √ |
| Forecasting COVID-19 cases in America and Brazil | [5] | Bayesian regression neural network, cubist regression, k-nearest neighbors, quantile random forest, support vector regression, and variational mode decomposition (VMD). | | √ |
| Predicting the future circumstances of a new Coronavirus in order to mitigate its effects | [6] | The recurrent neural network (RNN) based variants of long short term memory (LSTM): Stacked LSTM, Bi-directional LSTM and Convolutional LSTM and so on. | √ | |
| Providing a way to model, forecast, and evaluate the time incidence of a pandemic more simply. | [7] | Using non-central beta (NCB) probability density function and a probabilistic optimisation algorithm search for the best NCB model. | | √ |

Firstly, in the research [1] , SEIR and ARIMA models, in particular, provided health care as well as other services. For the projection of data, and their expansions were commonly used. In the research[3], to select the best-fitted parameters, a newly created approach derived from the famous Trust-region-reflective (TRR) technique is employed, and a MATLAB function entitled lsqcurvefit is used to apply the algorithm for the suggested pandemic model, tackling non-linear least squares problem. Moreover, below is a description of the LSTM learning process. The first phase is to gather real-time cases; the second step is to train the model using a rolling update mechanism, which updates the training sample sequence based on the real-time current prediction results. The model then chooses the Adam optimizer with a batch size of one and 500 rounds of training. Furthermore, the model uses Mean Square Error (MSE) as a loss function to determine the gradient descent direction and assess the error between true and predicted values.

Furthermore, BRNN, CUBIST, KNN, QRF, SVR, and VMD-based models need data analysis. The procedure is as follows: To begin, VMD is used to breakdown the dataset output variables into five IMFs. Second, each model is trained with each IMF using a time-slice validation approach. Finally, to construct multi-days-ahead COVID-19 case forecasting, a recursive technique is used.

The time series models based on the two-piece scale mixture normal (TP–SMN) distributions are discussed in this paragraph. The time series with the best match to a dataset was then chosen. To begin, examine the quality of fit of near-optimal NCB, epidemic models (SEIR, SIR, and SIS), and established time series formalisms (ARIMA and ETS). The next stage is to compare COVID-19's level of difficulty to that of nations that use NCB.

### B. Conclusions of ML Technology in Predicting Confirmed Cases and Trend

In this section, we draw a conclusion that there are a plenty of ML (Machine Learning) models proposed to predict the confirmed cases and trend of COVID-19. Moreover, to solve the specific problem, some innovative models are created. Some models combine with basic models of machine learning. And other models are proposed new models. In a word, ML(Machine Learning) makes great contributions to predicting the confirmed cases and trend.

## IV. COVID-19 Classification and Diagnosis Using ML-Based Images

TABLE III. ML Applications: COVID-19 Classification and Diagnosis Using ML-Based Images

| Categories | Publications | Methods |
|---|---|---|
| Chest X-ray images (CXR): distinguish the Chest-X ray (CXR) images of the novel | [8] | Dimensionality reduction approach, extraction of features from the whole CXR image |
| coronavirus patients from other forms of pneumonia. | [9] | Fractional Multichannel Exponent Moments (FrMEMs), modified Manta-Ray Foraging Optimization based on differential evolution. |
| CT Images: detect from CT images that the novel coronavirus shows different behaviours from other viral pneumonia | [10] | Grey Level Run Length Matrix, Grey-Level Size Zone Matrix, Grey Level Co-occurrence Matrix, Discrete Wavelet Transform algorithms, and Local Directional Pattern, Support Vector Machines (SVM). |

### A. Description of Classification and Diagnosis Using ML-Based Images

**Chest X-ray (CXR) images**: In a diagnostic research, COVID-Classifier[8], which is an automated machine learning model, was created to apply to the diagnosis of COVID-19 infection in chest X-ray images, which can accurately distinguish the chest X-ray images of COVID-19 patients from other forms of pneumonia. Scientists generate a series of optimal features of chest X-ray images with the help of a method about dimensionality reduction. The classifier needs relatively small dataset of CXR images, thanks to the use of universal features of the whole chest X-ray images. It is the identification and extraction of features from the whole Chest X-ray image instead of segment chest lesions that makes a distinct feature of this model.

In another study, scientists put forward a method aimed at COVID-19 chest x-ray image classification. [9] The features were extracted from the chest x-ray images with the assistance of new Fractional Multichannel Exponent Moments (FrMEMs). For accelerating the computational process, experts put forward a parallel multi-core computational framework. Then, the most significant features was selected with the aid of a modified Manta-Ray Foraging Optimization based on differential evolution.

**Computed Tomography (CT) images**: In a study, a ML-based Coronavirus detection presents was implemented on abdominal CT images, which can present early phase of novel coronavirus[10]. By taking different patches sized from CT images, four different datasets were shaped. Then the process of feature extraction was added to patches to improve the classification accuracy. In order to establish some feature extraction methods, Grey Level Run Length Matrix, Grey-Level Size Zone Matrix, Grey Level Co-occurrence Matrix, Discrete Wavelet Transform algorithms, and Local Directional Pattern were adapted. The classification of the extracted features used Support Vector Machines (SVM). The best classification accuracy was 99.68%.

### B. Conclusion of Classification and Diagnosis Using ML-Based Images

Machine learning (ML) methods make great contributions to identifying COVID-19 patients by analyzing their chest x-ray images and Computed Tomography (CT) images visually.

## V. Machine Learning Technology in Medical Resources Management

### A. Description of Application in Medical Resources Management

Table 4 above has already provided a list of all the applications in medical resources management that we studied. We will give a detailed introduction to all these applications in the following sections.

**Drugs**: For the prediction of the best drugs, researchers have done a series of experiments based on some ML-based models. Using 2 different learning databases about 3C-like protease inhibitors and proven active against CoV-virus, Ke et al [11] found 8 old drugs that were virtually effective in tackling feline infectious peritonitis coronavirus, and 5 more drugs were also recommended in the experimental environment. Jin Z et al [1] found a key protein structure which contributes a lot in the process of viral replication and transcription. On the basis of this discovery and Deep Docking platform, experts are able to design the drug target contrapuntally. Beck, B.R et al [12] used Molecule transformer-drug target interaction model and pre-trained it with Drug Target Common database and BingingDB database. They proposed an innovative molecule transformer-drug target interaction model and found an antiretroviral drug that is used to treat HIV can make great contributions to the medication of COVID-19. Inspired by the researchers studying the best drugs for treating Ebola and Zika virus, Ekins et al [13] have successfully built a model that can find the best drug for COVID-19 and other future pandemics.

**Vaccines**: When it comes to vaccines, machine learning can promote the rate of vaccinations and provide some proper methods for manufacturing vaccines. Researchers [14][15] have applied ML-based models in finding the most valid protein structure for the COVID-19 vaccine and proposed some methods that can increase the rate of vaccinations. One

group of researchers associated molecular structure data with biomedical information and used AI software to find the potential target for CoV diseases. The other group has applied models like SVM, RF, ANNs in virtual screening and DE NOVO design, and eventually, they successfully found some valid targets for CoV-virus.

TABLE IV. ML APPLICATIONS: MEDICAL RESOURCES MANAGEMENT OF TACKLING COVID-19

| Categories | Publications | Methods | Achievements |
|---|---|---|---|
| Prediction of best drugs | [1][11] | AI prediction model.<br>Deep Docking (a DL platform). | Identify 80 marketed drugs and choose 15 drugs which are found active.<br>Find the main protease and key enzyme in COVID-19 virus. |
| | [12] | MT-DTI (Molecule transformer-drug target interaction) | Predict some valid drugs like Antazanavir, darunavir, ritonavir .etc |
| | [13] | Computational models | Describe and discuss some promising SARS-CoV-2 viral targets and computational approaches |
| Design the structure of vaccines | [14][15] | RF, SVM, ANNs | The possible treatment for COVID-19.<br>Design new molecules |
| Predict the need for ventilation | [16] | Linear actuators | Successfully forecast the need for ventilation |
| ICU transfers | [17] | RF model | RF model was used for prediction |
| Operating rooms | [18] | Decision Tree Modeling | Provide a scheme for operating room management during COVID-19 |

**Ventilation**: The medical resources for tackling COVID-19 also includes the use of ventilation in a hospital. Shashikumar et al [16] studied 40 clinical variables and successfully predicted the requirements for ventilation in hospitalized patients.

**ICU transfers**: Comprehensively considering the factors like nursing assessment, vital signs, laboratory tests and so forth, Cheng et al [17] applied an RF model to forecast the ICU transfers within 24 hours of hospital admission successfully. With the assistance of the open-source Apache Spark project ML library, the model was trained with cross-validation and selected some features of ICU transfers. Finally, they predict the need for ICU transfers.

**Operating rooms**: In the research [18], experts have found that an operating room with a negative pressure environment is the most ideal one. What's more, a room complex comprising 3 separate small rooms was useful for preventing the spread of COVID-19 while operating on confirmed patients. Moreover, some new workflows like the coordination of staff, movement of surgical equipment were also created for designated isolation operating rooms.

### *B. Conclusions of Application in Medical Resources Management*

In this section, we conclude the ML-based application in medical resources management. This work can be divided into 5 parts, that is drugs, vaccines, ventilation, ICU transfers, and operating rooms relatively. As for drugs, Ke, Y.-Y, et.al.,[11] identify 80 marketed drugs and choose 15 drugs which are found active against COVID-19 with the aid of the AI prediction model. Beck, B.R, et.al[12] use MT-DTI to predict some valid drugs like Antazanavir, darunavir, ritonavir .etc. Ekins, S., et.al.[13] describe and discuss some promising SARS-CoV-2 viral targets and computational approaches based on the computational model. When it comes to vaccines, Yang X, Wang Y, et. al [14][15] applied kinds of algorithms like SVM, RF, and ANNs to design the structure of novel molecules and find new treatments for COVID-19. Moreover, Shashikumar et al [16] successfully forecast the need for ventilation with linear actuators. Cheng et al [17] successfully predict the need for ICU transfers within 24 hours on the basis of the RF model. Jolin Wong et al [18] provide a scheme for operating room management during COVID-19. The work above has laid a stable foundation for future studies in managing medical resources better and inspired the experts to put up with more efficient methods.

## VI. CONCLUSIONS

In our articles, we conclude 3 applications of ML-based models during the COVID-19 pandemic, that is confirmed cases prediction, image diagnosis, and medical resources management relatively.

When it comes to ML-based application in predicting confirmed cases, we concluded that some innovative models are created to solve the specific problem. Some models are combined with basic models of machine learning while others are proposed new ones. In a word, ML plays a crucial role in predicting the confirmed cases and trend.

As for the ML-based application in medical resources management, we choose drugs, vaccines, ventilation, ICU transfers and operating rooms these 5 parts to study. Some experts identify 80 marketed drugs and choose 15 drugs which are found active against COVID-19 with the aid of AI prediction model. Some researchers use MT-DTI to predict some valid drugs like Antazanavir, darunavir, ritonavir.etc. Others describe and discuss some promising SARS-CoV-2 viral targets and computational approaches based on computational model. When it comes to vaccines, a group of experts applied kinds of algorithms like SVM, RF and ANNs to design the structure of novel molecules and find new

treatment for COVID-19. Moreover, another group successfully forecasts the need for ventilation with linear actuators. Some experts successfully predict the need of ICU transfers within 24 hours based on RF model. A group of researchers provide a scheme for operating room management during COVID-19. This work has almost filled up the gap between the spread of COVID-19 and treatment and laid a stable basis for future studies.

When it comes to future research directions, a comprehensive review in other fields, such as deep learning and artificial intelligence (AI), is proposed. Furthermore, we are supposed to conduct more researches and investigations on studies solving the development of innovative and hybrid approaches to forecast the pandemic, classify and diagnose with medical images and methods about managing medical resources properly.

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