A Review of COVID-19 Diagnostic Methods

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Abstract

The new coronavirus disease 2019 (COVID-19) has recently emerged as an acute respiratory syndrome. The virus has spread throughout the world since the primary outbreak of the disease reported in Wuhan, China. The pandemic has led to increased mortality as the most important threat of the disease in specific populations across the world. Furthermore, COVID-19 has caused significant economic problems in several countries. The early diagnosis of COVID-19 is currently an important concern for physicians and communities. The present study aimed to review the published articles regarding the diagnosis of COVID-19 until the end of February 2020. According to the results we show that deep learning and machine learning algorithms can be effectively used to the scope of the disease.

Keywords: COVID-19, Coronavirus Disease, Deep Learning, Machine Learning, Diagnosis

1. Context

Similar to viruses such as SARS and MERS, coronaviruses infect both mammals and birds. In addition, they cause infections that normally emerge as a common cold in humans; however, the symptoms mostly differ in each species (1). Moreover, COVID-19 is closely related to SARS-CoV, which is often observed in bats. Evidence suggests that SARS-CoV originated in bats in China and has probably transferred to humans after transfer to an intermediate host. Similarly, MERS-CoV has been observed in camels in the Middle East and has been reported to transfer to humans (2). The other end of the spectrum encompasses COVID-19 species that cause common colds in humans with relatively mild symptoms (2).

The COVID-19 outbreak began in December 2019 in China and became a severe public health threat as an infectious disease, which has spread throughout the world, threatening the lives of individuals in every community (3, 4). Patients diagnosed with COVID-19 manifest various symptoms that are associated with respiratory tract infections, such as fever, cough, pneumonia, and even death (4).

According to the literature, the prevalence of this viral infection is higher in men than in women, and no deaths have been reported in children aged less than nine years (3). In many developed countries, the healthcare system is faced with a monumental challenge due to the increasing demand for special care units, mainly because Intensive Care Units (ICUs) have been rapidly occupied by the patients diagnosed with COVID-19, thereby leading to numerous issues in this regard (3).

In the medicine industry, the disease is diagnosed by tests and imaging, which are both time-consuming and extremely costly for patients. Therefore, physicians seek to find alternative techniques to reduce costs and time and prevent mortality by early diagnosis of the disease. A modern method is using deep learning and data mining algorithms. Various studies have been conducted in this field, which, despite their optimal performance, failed to achieve the desired accuracy due to problems such as long execution time or complexity of calculations. Meanwhile, the integration of these algorithms along with the use of feature extraction methods will lead to optimal diagnostic accuracy. In the present research, we covered some of the methods and studies conducted in the field.

The following sections of the current study are: a review of diagnostic methods for COVID-19 is presented in the second section, followed by the analysis of the techniques applied in this area in the third section. In the end, conclusions are provided in the fourth chapter.

2. Background Review

To date, no accurate diagnostic methods have been proposed for the COVID-19 infection. This is while the prevention of the COVID-19 outbreak requires a timely diagnostic option. Due to the short period since the spread of the disease, only brief research has addressed its diagnosis.

In a study ([5](#)), the Monte Carlo algorithm, which is considered to be the optimal predictive algorithm compared to the GROOMS method, was proposed for the diagnosis of COVID-19. In the mentioned study, two algorithms were combined to confirm the diagnosis, and the results of the combination of these algorithms led to flexibility in the accuracy of COVID-19 detection. Nevertheless, the Monte Carlo algorithm was reported to be superior to conventional diagnostic methods for the detection of COVID-19.

In another study in this regard, three models were used based on InceptionV3 and Inception-ResNetV2 neural networks, along with chest X-rays. In addition, the receiver operating characteristic curve and confusion matrix were used to analyze the results based on 5-fold cross validation. According to the results obtained from the proposed method, the pre-trained model of ResNet50 had the highest classification performance with 98% accuracy compared to the other two techniques (97% accuracy with InceptionV3 and 87% accuracy with Inception-ResNetV2) ([3](#)).

In a study ([6](#)), a machine learning model was proposed to predict artificial antibodies to potentially control COVID-19, and the results indicated the neutralization of thousands of hypothetical antibodies. Moreover, eight stable antibodies were observed to neutralize COVID-19 in the mentioned study. The interpretation of the machine learning model showed that mutations to methionine and tyrosine were remarkably effective in enhancing antibodies against COVID-19. A study ([7](#)) revealed that the emergence of the disease persuaded governments to decrease the infection rate and negative economic effects of the disease. In this regard, data mining techniques have been applied to measure the commercial risks associated with the COVID-19 pandemic.

In another study, the process and the time required for infection development were analyzed based on known macroscopic growth, along with the Gompertz and logistics laws, in various countries to assess the effectiveness of the inhibition of COVID-19 outbreak. In addition, the generalities regarding the Gompertz law were proposed in the mentioned study, in which the data analysis made it possible to assess the maximum number of infected cases ([8](#)).

Elmousalami and Hassanien ([9](#)) compared various predictive models for COVID-19 infection using the time series models and mathematical formulas. The existing predictions and models demonstrated that the number of COVID-19 patients will grow exponentially in the countries that do not adhere to quarantine rules and impose no restrictions on travel, public gatherings, and school, university, and work activity (i.e., social distancing). In previous research ([2](#)), the whole-genome sequence comparison revealed that the non-coding flanks of the viral genome could be used to accurately separate the four genera of coronaviruses.

A study ([10](#)) was conducted to develop a primary screening model for the diagnosis of COVID-19 pneumonia and influenza-associated pneumonia patients and distinguish them from healthy individuals using pulmonary CT imaging based on deep learning techniques. In addition, the images of coronavirus, influenza virus, and other infectious agents that are not associated with this virus were classified separately. Finally, the type of infections and the criteria of reliability and accuracy for COVID-19 were determined using the Bayes algorithm. In the mentioned study, the overall accuracy of 86.7% was obtained based on the results.

In a research study ([11](#)), the CT scan results of 88 patients with COVID-19 were collected from two hospitals in China. In total, 101 patients were reported to be infected with bacterial pneumonia, while 86 individuals were healthy. The experiment continued to modeling and making comparisons using a deep learning algorithm. According to the experimental results, the proposed model could accurately distinguish the patients with COVID-19 from those with an AUC of 0.95. In addition, the recall criterion was equal to 93.93, and the proposed model could distinguish COVID-19 patients.

In a study ([12](#)), 217 images were used as an experimental set, and the migration learning model was exploited to develop a diagnostic algorithm. In the mentioned study, it was assumed that deep artificial intelligence learning methods could extract the specific graphical characteristics of COVID-19, thereby providing a clinical diagnosis before pathogen testing, which resulted in saving the critical time required for controlling the disease. The findings of the mentioned research indicated 82.9% accuracy, 80.5% Specify, and 84% sensitivity for the applied methods.

In a study ([13](#)), deep learning methods were applied for the diagnosis of patients with COVID-19 using X-ray images. Among these methods, the support vector machine (SVM) algorithm and X-ray images were considered as the important classification features. In the proposed classification model (i.e., ResNet50), along with SVM achieved accuracy, FPR, F1 score, MCC and Kappa are 95.38%, 95.52%, 91.41% and 90.76%. Moreover, the ResNet50 classification model and SVM algorithm showed to have proper diagnostic ability compared to other classification models.

3. Analysis and Assessment

[Table 1](#) shows a summary of the methods used for the diagnosis of COVID-19. As observed, the deep learning algorithm and machine learning algorithms (SVM and neural networks) had the most application and highest accuracy in the detection of the virus. Deep learning is considered to

be an efficient tool for the rapid screening of COVID-19 and identifying high-risk patients, which may be beneficial for the optimization of medical resources, as well as the early prevention of the disease before the emergence of severe symptoms (14).

According to Table 1, deep learning and data mining techniques have been developed for the early diagnosis of Corona. In this regard, one of the common techniques is the DL algorithm, which is a deep-learning algorithm operating similar to the human brain in terms of structure and nature of work. The algorithm consists of several layers (latent layer) and uses mathematical models to understand the features of the input data. In addition, mapping from input to output occurs in the algorithm. Some of the considerable capabilities of the algorithm include recognizing trivial content, eliminating additional or repetitive information, and retrieve or generate new items if required.

The support vector machine (SVM) algorithm is another common method for diagnosis of COVID-19. SVM is a supervised learning algorithm that can classify and evaluate the desired criteria for diagnosis with good performance. One of the excellent features of the algorithm is its cost-effectiveness and shorter execution time for users, compared to other algorithms. Moreover, it has a low error rate and high scalability.

4. Conclusions

The present study reviewed COVID-19 diagnostic methods. According to the results, the deep learning algorithm and machine learning algorithms (e.g., neural networks) were most applicable for increasing the accuracy of COVID-19 diagnosis. Considering the studies in this regard and the rapid growth of classification methods, it is suggested that combined diagnostic methods be used to enhance the accuracy of the virus detection compared to the currently available methods.

Footnotes

Authors' Contribution: Collection, analysis and comparison of methods of diagnosing COVID19 disease.

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Table 1. Review of COVID-19 Diagnostic Methods

Column	Research	Datasets	Method	Conclusion
1	(5)	88 clinical samples	Monte Carlo; BFGS + PNN	RSME = 62077.26
2	(3)	50 patients selected from the open source GitHub repository	Deep learning; ResNet50; inceptionV3; inception-ResNetV2	Accuracy of inceptionV3: 98%; accuracy of inceptionV3: 87%
3	(6)	1887 Clinical samples from the	X-GBoost, random forest, multi-layer perceptron, support vector machine logistic regression	Accuracy of X-GBoost: 90.57%; accuracy of random forest: 89.18%; Accuracy of logistic regression:81.17%; accuracy of multi-layer perceptron: 78.23%; accuracy of support vector machine: 75.49%
4	(10)	618 clinical samples	Deep learning Bayesian	Accuracy: 86.7%
5	(11)	88 clinical samples	Deep learning	AUC=99%; ROC=93%
6	(12)	217 clinical samples	Migration neuro network; deep learning	Accuracy of migration neuro network: 82.09%; Specificity of migration neuro network: 80.5%; sensitivity of migration neuro network: 84%; accuracy of deep Learning: 73%; specificity of deep learning: 80.5%; sensitivity of deep learning: 84%
7	(13)	Repository of GitHub	ResNet50; SVM	Accuracy: 95.38%; FPR: 95.52%; F1 score: 91.41%; MCC: 90.76%
8	(15)	5372 samples from seven cities	Deep learning	AUC: 0.86
9	(16)		CNN	AUC: 0.99; sensitivity: 92.02; specificity: 98.02

References

1. Joyjinda Y, Rodpan A, Chartpituck P, Suthum K, Yaemsakul S, Cheun-Arom T, et al. First complete genome sequence of human coronavirus HKU1 from a Nonill Bat Guano Miner in Thailand. *Microbiol Resour Announc.* 2019;**8**(6). doi: 10.1128/MRA.01457-18. [PubMed: 30746519]. [PubMed Central: PMC6368654].

2. Wassenaar TM, Zou Y. 2019_nCoV/SARS-CoV-2: rapid classification of betacoronaviruses and identification of Traditional Chinese Medicine as potential origin of zoonotic coronaviruses. *Lett Appl Microbiol.* 2020;**70**(5):342–8. doi: 10.1111/lam.13285. [PubMed: 32060933]. [PubMed Central: PMC7165814].

3. Narin A, Kaya C, Pamuk Z. Automatic detection of coronavirus disease (covid-19) using x-ray images and deep convolutional neural networks. *arXiv Preprint arXiv.* 2020;**2003**:10849.

4. Zhu RF, Gao RL, Robert SH, Gao JP, Yang SG, Zhu C. Systematic review of the registered clinical trials of coronavirus diseases. *MedRxiv.* 2020. doi: 10.1101/2020.03.01.20029611.

5. Fong SJ, Li G, Dey N, Crespo RG, Herrera-Viedma E. Composite Monte Carlo decision making under high uncertainty of novel coronavirus epidemic using hybridized deep learning and fuzzy rule induction. *Appl Soft Comput.* 2020;**93**:106282. doi: 10.1016/j.asoc.2020.106282. [PubMed: 32362799]. [PubMed Central: PMC7195106].

6. Magar R, Yadav P, Farimani AB. Potential neutralizing antibodies discovered for novel corona virus using machine learning. *ArXiv preprint arXiv.* 2020;**2003**:8447. doi: 10.1101/2020.03.14.992156.

7. Stephany F, Stoehr N, Darius P, Neuhäuser L, Teutloff O, Braesemann F. The corisk-index: A data-mining approach to identify industry-specific risk assessments related to COVID-19 in real-time. *SSRN Electron J.* 2020;**2003**:12432. doi: 10.2139/ssrn.3607228.

8. Castorina P, Iorio A, Lanteri D. Data analysis on coronavirus spreading by macroscopic growth laws. *Int J Modern Phys C.* 2020;**31**(7). doi: 10.1142/s012918312050103x.

9. Elmousalami HH, Hassanien AE. Day level forecasting for coronavirus disease (COVID-19) spread: Analysis, modeling and recommendations. *ArXiv preprint arXiv.* 2020;**2003**:7778.

10. Nagendra KV, Rajesh MG. Deep learning system to screen coronavirus disease. *J Compos Theory.*

11. Song Y, Zheng S, Li L, Zhang X, Zhang X, Huang Z, et al. Deep learning enables accurate diagnosis of novel coronavirus (COVID-19) with CT images. *MedRxiv.* 2020. doi: 10.1101/2020.02.23.20026930.

12. Wang S, Kang B, Ma J, Zeng X, Xiao M, Guo J, et al. A deep learning algorithm using CT images to screen for corona virus disease (COVID-19). *MedRxiv.* 2020. doi: 10.1101/2020.02.14.20023028.

13. Sethy PK, Behera SK. Detection of coronavirus disease (COVID-19) based on Deep Features. *Preprint.* 2020. doi: 10.20944/preprints202003.0300.v1.

14. *A review of coronavirus disease-2019 (COVID-19).* 2020.

15. Wang S, Zha Y, Li W, Wu Q, Li X, Niu M, et al. A fully automatic deep learning system for covid-19 diagnostic and prognostic analysis. *MedRxiv.* 2020. doi: 10.1101/2020.03.24.20042317.

16. Butt C, Gill J, Chun D, Babu BA. Deep learning system to screen coronavirus disease 2019 pneumonia. *Appl Intell.* 2020. doi: 10.1007/s10489-020-01714-3.