



Optimizing AI Models for COVID-19 Detection and Forecasting: A Comprehensive Study

Abdelhameed Ibrahim^{1,*}

¹School of ICT, Faculty of Engineering, Design and Information & Communications Technology (EDICT), Bahrain Polytechnic, PO Box 33349, Isa Town, Bahrain

Emails: abdelhameed.fawzy@polytechnic.bh

Abstract

This systematic review explores the use of artificial intelligence (AI) and machine learning (ML) during the COVID-19 disease outbreak. AI/ML models may interpret medical images, auditory input, and patient records to diagnose early enough, thus enhancing the likelihood of positive patient outcomes. Coupled with optimization algorithms, deep learning methods have predicted COVID-19 from chest X-rays and CT scans with unprecedented high accuracy. This review, therefore, synthesizes the existing literature and looks at the significant emphases, gaps, and potential trends of applying AI in diagnosing COVID-19 and forecasting outbreaks. Further, the advancement of AI and ML in this domain needs to be known to enhance global preventive diagnostic techniques for future pandemics.

Keywords: AI; ML; Covid-19 Detection; Deep Learners; CNN; Chest X-ray

1. Introduction

The COVID-19 pandemic, resulting from the new coronavirus SARS-CoV-2, can be described as one of the most dangerous crises in international public health in recent years. This new virus emanated in late 2019 and has fiercely penetrated several parts of the globe, claiming the lives of millions of its infected persons. By demanding better and more accurate testing methods, there has been a focus on the effects of COVID-19 on patients and how they can be slowed down. The standard methods of diagnosing COVID-19 include the Reverse Transcription Polymerase Chain Reaction (RT-PCR). Nevertheless, these methods have several disadvantages; they are relatively expensive, often inaccessible, and the time required to achieve the results is extended. Moreover, expectations for high frequency and large scale to accommodate the surge during the 'wave' also reveal the inefficiency of the existing concept of healthcare facilities [1].

Due to such challenges, scholars have found possible AI and ML remedies to enhance COVID-19 diagnosis. In this way, the successful application of AI and ML technologies allows the processing of significant amounts of diverse and often seeming data: medical images, audio signals, and patients' records – for detecting such patterns that are difficult to recognize otherwise. Such technologies have proven to perform well in several areas within the health sector, such as diagnosing diseases, considering treatment, and predicting epidemics. Such systems enable faster diagnosis and help diagnose COVID-19 cases at an early stage, especially where adequate resources are lacking [2].

Deep learning has been a promising diagnostic tool in detecting COVID-19 from medical images, chest X-rays (CXR), and CT scans. These models can also change suddenly between COVID-19 pneumonia and others and can be bacterial or viral. Transfer learning CNNs and Feature extraction were used to train models

that provide nearly inconceivable mistakes in classifying infected and healthy patients. For this reason, several of the mentioned sources have demonstrated that AI solutions can accompany traditional diagnostic tools when options are scarce or when timely disease recognition is possible [3].

Furthermore, optimization algorithms, especially when integrated with AI models, are principal in enhancing those diagnostic methods and tools. The previous methods, such as data augmentation, feature selection and inclusion of hybrid models in the AI systems, have again improved the reliability and effectiveness of the systems. For example, many optimization algorithms, such as the Firefly algorithm, Whale Optimization Algorithm, and Genetic Algorithms, were employed to select features from the medical datasets and improve the models' performance indicators. This optimization also enhances diagnostic accuracy and helps reduce the computational demand as the model becomes more realistic and retrievable in definite healthcare settings [4].

It is noteworthy that AI and ML technologies have been widely used not only to identify the disease but also to predict its further spread. Forecasting models help understand the data and distinct trends, including infection incidence, human mobility, and healthcare facilities' capability to contain the infection and manage the human impact. This predictive capability also enables governments and health organizations to make strategic decisions concerning resources, restrictions, and vaccines. Due to the effectiveness of utilizing machine learning for outbreak forecasting, the approach has shown appreciable promise in not only coping with COVID-19 but also other epidemic diseases [5].

This systematic review seeks to present a detailed literature review on COVID-19 diagnosis and outbreak prediction using AI and ML. Categorizing the research papers of the last few years, the study will illustrate different AI approaches, data and optimization for improving COVID-19 detection systems. Besides, the review will consider the achievements, challenges and future trends of using AI in public health. The target is to present statements for which subsequent studies and development are to be provided, creating the path towards more accurate, reproducible, and available diagnosis resources that are valuable in present and future imminent epidemics.

In conclusion, The COVID-19 pandemic has exposed the necessity of developing more effective diagnostic modalities than the now familiar and seemingly overburdened RT-PCR test. AI and ML have proved viable options for the healthcare industry, which they use to diagnose ailments through diverse, complicated images and patient data. The CNNs competently detect COVID-19 from CXR and CT scans with high accuracy rates, even more so when combined with optimization models. Furthermore, the studies of the ML models have shown accuracy in forecasting a virus and, as a result, its impact on resource management and public policies. This review will review the latest achievements, issues, and prospects of using AI for COVID-19 diagnostics and prognosis.

2. Literature Reviews

COVID-19 has brought into sharp focus the importance of accurate diagnostic techniques for detecting communicable diseases. Problems associated with existing approaches, including limited access to RT-PCR, its high cost, and the long time needed to provide results, have led researchers to look for alternatives. The emergence of AI and ML technologies has created a new line of research to integrate into creating automated systems that help predict COVID-19 outbreaks. These technologies utilize medical images, sounds, and IT data to improve diagnostic abilities and speed. This paper provides a brief of empirical research done in the last five years on using AI/ML methods for efficient COVID-19 diagnosis with specific details on the method used and the nature of data used next.

According to the study described in [6], an optimized deep learning (DL) scheme was proposed to differentiate infected COVID-19 patients from healthy ones by using CT scans. The study answers the difficulties related to proving the authenticity of classifiers for precise diagnosis, an issue considered for many years in computer vision, becoming the focus again during the COVID-19 pandemic. Many clinical diagnoses entail an extended processing time and comparatively low sensitivity, particularly in the early stage of the disease; in contrast, the proposed approach applies contrast enhancement techniques, improving CT image quality. The DenseNet-201 model was pertained; fine-tuning was done using the transfer learning technique, and feature extraction was done with 2 fully connected layers and 1 average pool. For these features, the Firefly algorithm was used to select the best features in learning that give the best accuracy. The

study also developed a new parallel high index technique to integrate two optimal vectors, and an extreme learning machine classified the vectors. Experimental results, based on a 70: and 30 training and testing Split, showed that the proposed approach achieved 94.76% average classification accuracy, and the result shows that this approach is considerably good compared to other DL models.

As highlighted in [7], our study emphasizes the need to rapidly and accurately diagnose COVID-19 to prevent the spread of the disease through isolation and medical management rather than with a vaccine that has not yet been developed. As new cases of COVID-19 infection continue to rise every day, and testing kits remain scarce, the study presents a diagnostic model for COVID-19 based on chest X-ray images and deep neural networks. The approach involves four phases: data augmentation, preprocessing, and the two-stage deep network model architecture. By training a deep network on an online dataset comprising 1215 images and an augmented dataset of 1832 to enhance generalization and prevent overfitting, the network learns to distinguish COVID-19 pneumonia from other pathologies such as bacterial and other viral pneumonia. The model was also tested using training-validation-testing and 5-fold cross-validation techniques. We got high classification accuracy rates of 97.77% for both techniques, while recall and precision rates were 97.14%. The architecture also revealed similar favorable results with averaged metrics of 98.93% accuracy, 98.93% sensitivity, 98.66% specificity, 96.39% precision and an F1 score of 98.15, which underlines the practical statistical capacity in identifying COVID-19 using X-ray images.

In the research presented in [8], Coronavirus, which manifests itself in several respiratory diseases such as pneumonia, was identified via deep learning, an artificial intelligence component. The study employed a dataset comprising COVID-19, influenza, bacterial pneumonia, and healthy control chest X-rays. To increase the amount of data that has to be analyzed, the Fuzzy Color technique was used as the initial step of data preprocessing; the preprocessed images were merged with the initial ones to create a second dataset. This data set was then used to build two deep learning models: MobileNetV2 and SqueezeNet. The features obtained from these models were then fine-tuned using the Social Mimic optimization method through which the right features were sourced. Support Vector Machines (SVM) then again classified these optimized features, and an overall classification accuracy of 99.27% was achieved. The proposed method shows the applicability of deep learning models in the early identification of COVID-19-positive individuals, a valuable resource for diagnosing and controlling outbreaks.

As pointed out in [9], COVID-19 is a new virus topping both the upper respiratory tract and lungs; thus, there is a need for efficient diagnostic techniques due to the increasing number of cases and deaths caused by the virus across the globe. Chest X-ray imaging used in tracking lung diseases has been employed in identifying COVID-19. This study used different DL algorithms to distinguish COVID-19 and healthy CXR images: deep features' extraction, adjustment of the structure of the pre-trained CNNs and end-to-end training of the new CNN model. In particular, ResNet18, ResNet50, ResNet101, VGG16 and VGG19 were used for feature extraction, and the classification process was performed using SVM with Linear, Quadratic, Cubic, and Gaussian Kernels. The research also extended to retraining these pre-trained models and trying a few experiments using the custom CNN model for end-to-end learning. After analyzing the chest X-rays of 180 COVID-19 and 200 regular patients, the study determined that the deep features extracted from the ResNet50 and support vector machine with linear kernel algorithm had the highest accuracy percentage of 94.7%. Specifically, when transferring the fine-tuned ResNet50 model derived from the CIFAR-10 data set, the picture recognition accuracy reached 92.6%. In contrast, the new CNN model developed based on this paper only obtained 91.6%. For further benchmarking, local texture descriptors were employed together with SVM classifiers, and these results established that deep learning techniques offered much higher accuracy than these conventional methods, confirming the effectiveness of the proposed approaches for identifying COVID-19 from lung X-ray images.

, as is brought out in [10]. Finally, early diagnosis of COVID-19 is vital in containing the spread of the disease and proper management of affected patients" Cele et al. (2020). The study created a combination of an artificial intelligence model named COVID-19 AIMDP, with the main aim of diagnosing COVID-19 cases and differentiating them from other types of viral pneumonia by analyzing chest CT scans. CNNs are applied in AIMDP to analyze numerous CT images for COVID-19 case prediction to help in early containment. For feature selection, the whale optimization algorithm (WOA) was used so that only the most appropriate patient signs were used for diagnosis. AIMDP was used in several experiments to test its performance, and it was

shown that its use improved AUC-ROC, PPV, NPR, and NPV. AIMDP was used in an experimental setting on a 100 real patient data dataset, and CT images; its diagnostic accuracy reached 96% based on the AUC and overall accuracy of 98%. Overall, these results evidence AIMDP's potential and demonstrate that AIMDP exhibits higher accuracy in identifying COVID-19 cases than other recent diagnostic and predictive models.

Following the work of [11], COVID-19, now the WHO-declared pandemic, quickly spread across the globe. Therefore, quick diagnosis was paramount to prevent the contagious spread of the virus, test individuals with the virus and attend to them accordingly. Due to the shortcomings of diagnostic kits and the high virus infection rates, auxiliary detection tools have become crucial. This paper presents a new deep-learning model that improves COVID-19 detection to augment CT scan images. The pooling layer involves standard and Squeeze Excitation Block (SE-block) pooling to enhance feature extraction efficiency. To improve the model performance and converge faster, batch normalization and the Mish activation function were used. The proposed model's performance was evaluated on a dataset from two public hospitals and compared with other selected typical DNNs. Experimental results revealed that the specificity was 99.03 %, while the recognition time was 0.069 milliseconds, and it was a GPU-based algorithm. The analysis of the results obtained in the study shows that the proposed model surpasses other networks in classification criteria and real-time usage, providing an opportunity to use the model as an effective and fast means of COVID-19 identification.

In the analysis carried out in [12], the study relates to COVID-19, a virus that originated from Wuhan, China, in early 2020 and infected many dollars; lives were lost. Besides the diagnostic test kits, images like X-rays have helped diagnose COVID-19, especially for persons with lung complications. The research proposed a novel deep learning approach named DeepCovNet, designed to classify chest X-ray images into three categories: Classification of images: COVID-19, normal (healthy), and pneumonia. The method uses a convolutional-autoencoder, which comprises convolutional layers in both the encoder and decoder to extract deep features from the processed chest X-ray image data. SDAR, a robust algorithm, was used to choose the most discriminant features from the extracted set. A Support Vector Machine (SVM) with a range of kernel functions was applied for classification. Then, the hyperactive parameters of that model were tuned using a Bayesian function to improve the classification results. The performance measurement indicators used are specificity, sensitivity, precision, F-score, and accuracy. The above-stated method offered an accuracy of 99.75%, which outcompeted other deep-learning diagnostic methods in establishing its efficiency in diagnosing COVID-19 based on chest X-rays.

As outlined in the paper [13], the number of deaths caused by the SARS-CoV-2 virus has increased worldwide, and researchers have sought technological enabling approaches that may help physicians treat COVID-19 cases. Sensitive and effective AI methods are now required to assess the potential severity and mortality rates of the COVID-19 virus to ensure timely treatment and appropriate usage of the models' computational capacities in hospitals. This case aims to develop a risk prediction model that predicts different severity risks of COVID-19 patients based on X-ray images using machine learning for clinicians' decision-making. The proposed model, therefore, integrates a CheXNet DL model with a hybrid extraction of handcrafted features. To improve the feature selection process, the authors used PCA with RFE and showed that using features selected by both methods (PCA + RFE) achieved better results than using only one. Six classifiers were applied, revealing that XGBoost yielded the highest accuracy of 97 percent, precision of 98 percent, and recall of 95 percent, F1-score of 96 percent and ROC-AUC of 100 percent when the features were merged. Similar results were obtained with the SVM classifier, slightly different, where the accuracy was 97% while the precision, recall, F1-score, and ROC-AUC were 96%, 95%, 95%, and 99, respectively. For feature extraction using the pre-trained CheXNet model, it was found that Extra Tree and SVM classifiers with RFE had near-ceiling performance across all metrics—with a 99.6% accuracy success rate. Based on these discoveries, it can be stated that a hybrid system based on deep learning and machine learning can be used to predict COVID-19 severity from chest X-ray images while providing new approaches to managing severe cases at the early stage.

As stated in [14] Footnote 4 below, Infectious diseases – including COVID-19, are risky due to their potential to infect many people across the globe. The COVID-19, or coronavirus disease of 2019, was attributable to the SARS-CoV-2 virus, began in Wuhan, China, in December of 2019, and shortly became an ongoing pandemic that threatened the capacities of overall healthcare systems across the globe. After the outbreak of the COVID-19 virus, there has been increased pressure towards achieving fast and effective diagnoses. Chest

X-ray (CXR) and computed tomography (CT) scans are now primary diagnostic tools in discovering this disease at an early stage. This work aims to determine the best approach to deep transfer learning to develop a highly accurate COVID-19-positive patient classifier using CT and CXR imaging. Some of the difficulties outlined include issues related to overfitting. Therefore, to handle this problem, several data augmentation methodologies were applied to the training data set. While using data augmentation, the research investigated several pre-trained deep neural architectures, such as ResNet50, InceptionV3, VGGNet-19, and Xception. These showed that deep learning models working in healthcare did an excellent work of diagnosing COVID-19. When each imaging modality was analyzed separately, the_vggnet19, The proposed model performed well in detecting tumors from CT images with a precision of 88.5 %, recall of 86 %, F1 score of 86.5, and accuracy of 87%. For CXR images, the updated model of Xception provided them with the best outcomes for precision, recall, F 1-score, and accuracy, which were all 98% each. The performance of all four models improved when the results of both CT and CXR were combined; the VGG-19 showed the highest scores in the experiment: accuracy=0.905, F1-score=0.905, recall=0.903, precision=0.915. These outcomes show the possibilities of utilizing deep transfer learning for automating the evaluation of chest CT scans and x-ray images where access to the RT-PCR tests may be limited.

According to the study discussed in the paper [15], the World Health Organization as a Public Health Emergency of International Concern characterized the COVID-19 outbreak. The sickness mainly impacts the lungs; hence, precise identification from other lung disorders is challenging due to respiratory system complications and infections. In particular, healthcare practitioners must gauge the true extent of the patient's condition to provide potentially life-saving aid. This research developed a two-stage pipeline for identifying COVID-19 cases and predicting the severity of the illness based on lung CT images. First, feature extraction was done with the transfer of feature extractor pre-trained models comprising Alex Net, DenseNet-201, and ResNet-50. COVID-19 identification was carried out using an Artificial Neural Network (ANN) model to distinguish if a patient was infected. After the detection phase, the level of infection was determined. This was achieved by combining image features with clinical data, classifying the severity into three categories: High, Moderate, and Low and was classified using a Cubic Support Vector Machine (SVM). This classification increases the identification of high-risk diabetic patients so they can be offered more "intensive care." The method was first tested on a publicly available dataset and gave an accuracy of 92.0%, a sensitivity of 96.0% and an F1-Score of 91.44% in COVID-19 detection. Accuracies for the model were 96.0% for the distinction of moderate and mild levels and 90.0% for the severity classification across the three levels. The findings of this study not only validate the use of deep learning algorithms in conjunction with clinical data for COVID-19 diagnosis but also offer a promising future for assessing illness severity and improving patient care.

In the publication [16], machine learning is used to detect Coronavirus from CT lung scans, a severe acute respiratory disease associated with a deadly virus that quickly spreads. According to WHO, over half a million people have died, while the global infection rate stood at more than twelve million? Since the development of an effective vaccine has not been realized, early detection has become one of the main strategies to combat the virus and reduce potential damage to the patient's lungs. RT-PCR testing has been implemented as a primary diagnostic method in COVID-19 cases. However, in some circumstances, CT has served as a potential diagnostic and screening modality with even better sensitivity and cost-effectiveness. This has led researchers to seek ways of creating a CAD system that could help radiologists diagnose the virus in lung images. This paper aims to design a CAD system to detect and categorize COVID-19 in CT images using machine-learning approaches. The proposed system consists of four main phases: It comprises the following steps: (1) data acquisition of CT lung screening data; (2) preprocessing to increase the contrast and make nearly invisible GGOs easily distinguishable; (3) identification of ROIs using an improved K-means clustering algorithm; and (4) classification using the machine learning techniques such as RBFs and SVM. Specifically, the study evaluates false negatives by proposing to analyze typical features after thresholding and filtering functions. Finally, this CAD system envisions better identifying COVID-related lesions on lung CT images, improving patient management and care.

In the work described in [17], a new approach using Reinforcement Learning is introduced for detecting COVID-19 alongside cases of viral pneumonia and standard cases from chest X-ray images. The proposed work uses a Fuzzy Reinforcement Learning algorithm, optimized by JAYA, with Wavelet Transform for feature extraction and PCA for feature reduction in developing the proposed classifier; COVID-19: 87.75%,

Viral Pneumonia: 95.63%, Normal Cases: 96.89%, giving an overall classification accuracy of 93.43%. These results mean that the proposed JAYA-Optimized Fuzzy Reinforcement Learning approach is not only accurate but also better or at least comparable to several state-of-art classifiers such as Support Vector Machines, Artificial Neural Networks, Tree based algorithms, and K-Nearest Neighbors. Therefore, the main idea of the work is to develop a classifier that can classify COVID-19 cases and regular and viral pneumonia from chest X-ray images. This classifier must be online, adaptive, accurate, and fast; it has significant diagnostic potential for healthcare professionals during the pandemic. The findings demonstrate that the adoption of high-level machine learning methods in diagnostic processes and decision-making can become beneficial during focused mass-related disease pandemics.

2020 will remain a record for humanity when the world had to deal with a pandemic that affected people on the entire planet. The COVID-19 pandemic changed people's social and daily lives, posing severe threats to economies and international relations. Against this unpredictable calamity, healthcare facilities worldwide struggled to deal with high patient cases at the emergency wards and intensive care units. Conventional tests for COVID-19, therefore, were expensive, slow, inaccurate, and widely available. Most importantly, they failed to isolate infected persons quickly and promoted the high transmission rate of the virus. In the publication discussed in [18], a new approach suggests using affordable X-ray imaging to diagnose patients with COVID-19. Many patients in healthcare facilities undergo X-ray imaging since it is more accessible than other imaging techniques. In this proposal, feature learning and classification will be done through a multi-stream Convolutional Neural Network. The model effectively extracts and concatenates features from three input images: LSB and HoG. Many experiments were performed using five-fold cross-validation for the tested dataset, which had 3886 X-ray pictures in three classes of images made available to the public. The proposed model showed better performance than the existing one and with better accuracy of 97.76 percent. These findings show evidence that the model could significantly reduce the growing burden on HC systems by offering an AI-based automatic diagnostic system that improves the population's COVID-19 diagnosis and control.

COVID-19 has caused a global health problem, and several protective measures have been taken to minimize the virus transmission. The WHO also advises wearing a facemask outside the house, one of the measures acknowledged as most efficient. The paper [19] presents a deep learning and classical machine-learning model for facemask detection to meet this public health need. The proposed model is composed of two major streams. The first component is part feature extraction using ResNet50 architecture, the model that extracts deep features from images. The second component is inherent to classifying the usage of facemasks wherein various classifiers such as Decision trees, Support Vector Machines (SVM), and Ensemble algorithms are used. To evaluate the performance of the model, three distinct face mask datasets were utilized: The real-world nature of the same is higher that is evident from the Real-World Masked Face Dataset (RMFD), Simulated Masked Face Dataset (SMFD), the Labeled Faces in the Wild (LFW). These outcomes also show a high accuracy level in facemask detection, where Region-Based Classifier SVM yields a testing accuracy of 99.64% on a thousand datasets of RMFD, 99.49% on hundred datasets of SMFD and one hundred percentage of accuracy on one dataset of LFW. This study suggests that integrating deep learning and classical machine learning models can significantly improve facemask identification and may be a powerful tool in combating COVID-19 infection.

In the present era of increased transmission of [20] COVID-19, the ability to identify COVID-19 cases has emerged as a challenge to the scientific community, the medical profession, and policymakers. It could be sad to establish that by April 23, 2020, the situation was so seemingly bad, with about 2,7 million confirmed cases, over 190000 deaths and about 750000 cases of recovery all over the world. However, a problem is the need for more transparent information about the tests, which can contribute to the uncontrolled spread of the virus and make the fight against the pandemic more difficult. One of the most discussed challenges has been the case of false-negative test results. Such inaccuracies give a wrong perception to the general public and health officials; infected individuals may continue to transmit the virus without their knowledge. Factors that explain false negatives are sample size, test time, and diagnostic tool types. Therefore, improvement in the methods used in detecting these challenges is vital. This can entail enhancing the efficacy of the present detection methods, enhancing the accessibility of the test and expanding the use of technologies such as machine learning and artificial intelligence to complement diagnostic procedures. Moreover, regular and open reporting of the testing data is needed for greater transparency and better strategy development

regarding the COVID-19 crisis. Solving the dilemma of detection accuracy will involve all sectors of society, including healthcare, information technology and government, especially in ministries of health, to support timely and appropriate responses to this world health issue.

As discussed in the paper [21], the progression of COVID-19 escalated the need for complementary methods other than PCR and resulted in the integration of X-ray imaging and AI. Several techniques have been widely used in medical image analysis, such as the convolutional neural network (CNN) and deep learning models, which are proven to produce valuable features from medical images to diagnose accurately. The study proposed a method involving an Xception neural network enhanced by a genetic algorithm to achieve that. Therefore, the GA uses different depth levels for the given type of layers, parameters, and other options to fine-tune network architecture to reach higher efficiency. The proposed optimized network was then tested on the COVID-19 X-ray image dataset, and its performance was compared to other models proposed in the existing literature. The results proved that the GA-optimized Xception network has better recognition accuracy, and it gained 0.996 for the two-class datasets, 0.989 for the three-class datasets, and 0.924 for class datasets. Geographically, the implication of utilizing enhanced neural network optimization is increasing the diagnostic outcomes on COVID-19 from x-ray images.

A new diagnostic strategy was proposed in the presented study in [22] to improve the sensitivity of the COVID-19 diagnosis by integrating Dense Net architecture into the OTLS strategy for the transfer-learning environment. These included data initialization steps such as brightening, contrast stretching, and separating chest CT images to encompass more training data through data augmentation. A composite learning factor (CLF) was used to control the learning rate of frozen, middle, and new layers, ensuring more effective feature extraction and model learning. The proposed OTLS strategy fine-tuned the learning process more, and the precomputation technique was employed to reduce the RAM utilization and enhance the speed of the process. In the optimization setting, it was seen that “201-IV” was useful and provided excellent diagnostic performance. It gave a sensitivity of $96,35 \pm 1,07$, specificity of $96,25 \pm 1,16$, precision of $96,29 \pm 1,11$, and accuracy of $96,30 \pm 0,56$ and hence corroborated the capability to diagnose COVID-19 using CT images compared to plethora of state-of-art techniques.

A new global virus called coronavirus disease-2019 (COVID-19) emerged recently, creating unprecedented challenges for human society in China and worldwide. According to the findings in the paper [23], COVID-19 infected the lungs of human hosts and tended to spread quickly. More of the patients who were infected by the virus would suffer severe symptoms, and some could develop significant organ failure or die. In this work, the authors employed machine-learning algorithms to develop a model for diagnosing the severity of COVID-19 cases. In this case, a Support Vector Machine instrument was used, which showed good accuracy after the author identified 32 features with a significant relation to the severity of the disease. After filtering out features that are redundant between features, the model was optimized for an accuracy of 81.48% using only 28 features. This study may aid in evaluating the probability of developing severe symptoms in COVID-19 patients. Furthermore, the reported 28 reporters might point to the pathways in the course of the development of the infection.

As mentioned [24], classifying early lesions can help diagnose COVID early, possibly preventing complications like severe pneumonia. The study proposed a Hybrid Classification Optimization (HCO) approach using Recurrent Learning and Fuzzy (RLF) methods to detect infections in CT scan images of lung regions. The neural network determines the infected and non-infected regions using the statistical distribution of pixels and their standard deviation. This entails missing features that are not apparent and missing regions that are learned using recurrent networks. Recurrent learning, in turn, knows the region based on training correlations and input datasets.

In contrast, fuzzy logic fills in the gap of the features using the clinical data with other derivatives of that population out in the variability range. Attempts to predict the infected regions of interest with this method incorporate maximum fuzzy derivatives while omitting minimal ones to reduce the incidence of false positive reports. Such a combined approach leads to better uniformity during training, which resulted in improvements in detection, classification accuracy and precision rates of 11.96%, 9.98% and 13.42%, respectively, over existing ones like DR-MIL, DSAE and BS-FSA.

Because of the work undertaken in [25], a novel solution was found for one of the significant issues in the fight against COVID-19: the early diagnosis of the disease using cough audio signals. Most traditional diagnostic techniques need a relatively long turnaround and, therefore, are tricky for early screening. Thus, this research presented an ensemble deep learning model based on heuristic evolution purposefully deployed for quick and precise diagnosis. The approach starts with capturing audio signals from a source and shifts to further refining or analyzing these signals by subsequent application of Empirical Mean Curve Decomposition (EMCD). After this decomposition process, Mel Frequency Cepstral Coefficients (MFCC) and some spectral and statistical features are extracted. Later, these features are combined, and the optimal weights for each are determined from the combination provided by Modified Cat and Mouse Based Optimizer (MCMBO). The last stage includes fitting these optimally weighted features into the Optimized Deep Ensemble Classifier (ODEC), where classifiers such as Radial Basis Function (RBF), Long-Short Term Memory (LSTM) and Deep Neural Network (DNN) are included. The parameters of the ODEC are optimized using the MCMBO algorithm to improve detection efficiency. The validation results showed that the method reached 96% accuracy and 92% precision, which indicates the method's usefulness for timely and accurate COVID-19 diagnosis that would assist healthcare providers in proactive measures.

Table 1 presents a detailed list of numerous studies, and the ML and DL models applied in improving the identification, diagnosis, and prognosis of COVID-19. All the studies use different forms of data, such as CT scans, chest X-rays, and cough audio signals, which shows the flexibility required for the AI model to handle medical data. The four identified techniques, feature extraction, data augmentation, optimization algorithms and Hybrid model, are highlighted, suggesting their importance in enhancing accuracy and resilience. For example, DenseNet-201, ResNet50 and CheXNet were employed in the analysis because they can identify rich features from the medical images. Other methods, including Firefly, Whale Optimization, and Genetic Algorithm, were also incorporated into the feature selection and the model. Admittedly, the indicated accuracy rates vary from 81.48% to 99.75%, as well as precision, recall, and ROC-AUC scores and suggest that the AI models can improve early and accurate diagnosis of COVID-19, which will contribute to proper management of the disease.

Table 1: Summary of Literature Review

Study	AI/ML Method	Data Type	Key Findings
[6]	Optimized Deep Learning (DL) scheme	CT scans	94.76% average classification accuracy using DenseNet-201 and Firefly algorithm.
[7]	Deep Neural Networks	Chest X-ray images	97.77% classification accuracy, 98.93% sensitivity, 98.66% specificity, 96.39% precision, and 98.15% F1 score.
[8]	Deep Learning (MobileNetV2, SqueezeNet)	Chest X-ray images	99.27% overall classification accuracy using the Fuzzy Color technique, Social Mimic optimization, and Support Vector Machines.
[9]	Deep Learning (ResNet18, ResNet50, ResNet101, VGG16, VGG19)	Chest X-ray images	94.7% accuracy using ResNet50 and SVM with linear kernel.
[10]	COVID-19 AIMDP (Artificial Intelligence Model)	Chest CT scans	96% diagnostic accuracy using CNNs and whale optimization algorithms.
[11]	Deep Learning Model	CT scan images	Using standard and Squeeze Excitation Block pooling, 99.03% specificity and 0.069 milliseconds recognition time.

[12]	DeepCovNet	Chest X-ray images	99.75% accuracy using convolutional-autoencoder, SDAR, and SVM.
[13]	CheXNet DL model	Chest X-ray images	97% accuracy, 98% precision, 95% recall, 96% F1-score, and 100% ROC-AUC using PCA+RFE and XGBoost.
[14]	Deep Transfer Learning	CT and CXR images	98% accuracy, 98% precision, 98% recall, and 98% F1-score using the Xception model for CXR images.
[15]	Two-stage pipeline (feature extraction and classification)	Lung CT images	92.0% accuracy in COVID-19 detection, 96.0% accuracy in distinguishing moderate and mild levels, and 90.0% accuracy in severity classification.
[16]	CAD system using machine learning	CT lung scans	High accuracy in detecting COVID-related lesions using K-means clustering and RBFs/SVM.
[17]	JAYA-Optimized Fuzzy Reinforcement Learning	Chest X-ray images	93.43% overall classification accuracy.
[18]	Multi-stream Convolutional Neural Network	X-ray images	97.76% accuracy in diagnosing COVID-19.
[19]	Deep Learning and Classical Machine Learning	Face images	99.64% accuracy in face mask detection using the RMFD dataset.
[20]	Xception neural network enhanced by a genetic algorithm	X-ray images	0.996 accuracy for two-class datasets, 0.989 for three-class datasets, and 0.924 for class datasets.
[21]	OTLS strategy with Dense Net architecture	Chest CT images	96.30% accuracy in diagnosing COVID-19.
[22]	Support Vector Machine	Clinical data	81.48% accuracy in predicting the severity of COVID-19 cases.
[23]	Hybrid Classification Optimization (HCO)	CT scan images	11.96% improvement in detection, 9.98% improvement in classification accuracy, and 13.42% improvement in precision rates compared to existing methods.
[25]	Ensemble deep learning model	Cough audio signals	96% accuracy and 92% precision in diagnosing COVID-19.

Reviews presented in this section prove that AI-based methods can be helpful in the diagnosis of COVID-19 and the management of the disease. A range of approaches, including deep learning, feature extraction, and optimization techniques, leads to high accuracy and better differential performance across different datasets. However, it is clear that there are some limitations; future studies should achieve larger data sets, future studies should be replicated in other populations, and future work needs to embed these markers into clinical

practice. More studies must show how to address these problems while investigating novel AI technologies to strengthen pandemic readiness and management. In general, AI and ML have great potential for development in the field of Public Health, including the prevention and control of the present and potential future epidemic diseases.

3. Conclusion

Altogether, the application of AI and ML has seen promising prospects in diagnosing COVID-19 and predicting the outbreak of such diseases. Standard procedures such as RT-PCR are as effective but costly and timely as current rapid antigen tests. Other possible models include artificial intelligence (AI) accompanied by the DL approach, which has more apparent advantages since it is capable of handling Big Data, which is characterized by its heterogeneity, as well as medical images, such as CT scans and X-rays, and audio signals in order to diagnose the patient more accurately and quickly. Several papers indicated that convolutional neural networks (CNNs) could accurately diagnose COVID from chest X-rays and CT scans. Furthermore, better diagnostic performance was achieved by incorporating the Firefly and Whale Optimization algorithms to formulate the feature selection stage. AI has also been used to predict the number of infected people and has assisted government and health organizations in planning how to allocate their resources best. Nonetheless, limitations exist today, including data input, external validity, and adoption of the models in practice. The following research areas are recommended: broadening datasets, enhancing models' resilience to adversarial variations, and guaranteeing more ethical and transparent approaches to AI usage. Altogether, the application of AI and ML exhibits potential in public health as new strategies for controlling present and future emerging infectious immunopathological outbreaks.

References

- [1] L. Wang et al., "Artificial Intelligence for COVID-19: A Systematic Review," *Front Med (Lausanne)*, vol. 8, p. 704256, Sep. 2021, doi: 10.3389/FMED.2021.704256/BIBTEX.
- [2] C. Qin, H. Ma, M. Hu, X. Xu, and C. Ji, "Performance of artificial intelligence in predicting the prognosis of severe COVID-19: a systematic review and meta-analysis," *Front Public Health*, vol. 12, p. 1371852, Jul. 2024, doi: 10.3389/FPUBH.2024.1371852/BIBTEX.
- [3] F. N. Iandola, S. Han, M. W. Moskewicz, K. Ashraf, W. J. Dally, and K. Keutzer, "SqueezeNet: AlexNet-level accuracy with 50x fewer parameters and <0.5MB model size," Feb. 2016, Accessed: October 20, 2024. [Online]. Available: <http://arxiv.org/abs/1602.07360>
- [4] K. Archana, A. Kaur, Y. Gulzar, Y. Hamid, M. S. Mir, and A. B. Soomro, "Deep learning models/techniques for COVID-19 detection: a survey," *Front Appl Math Stat*, vol. 9, p. 1303714, Nov. 2023, doi: 10.3389/FAMS.2023.1303714/BIBTEX.
- [5] A. Kaur, N. Singla, and N. Naj, "Comparative study of Covid-19 using machine learning models," *AIP Conf Proc*, vol. 2978, no. 1, Jan. 2024, doi: 10.1063/5.0191610/3037446.
- [6] M. A. Khan et al., "Classification of Positive COVID-19 CT Scans Using Deep Learning", doi: 10.32604/cmc.2021.013191.
- [7] G. Jain, D. Mittal, D. Thakur, and M. K. Mittal, "A deep learning approach to detect Covid-19 coronavirus with X-Ray images," *Biocybern Biomed Eng*, vol. 40, no. 4, pp. 1391–1405, Oct. 2020, doi: 10.1016/J.BBE.2020.08.008.
- [8] M. Toğaçar, B. Ergen, and Z. Cömert, "COVID-19 detection using deep learning models to exploit Social Mimic Optimization and structured chest X-ray images using fuzzy color and stacking approaches," *Comput Biol Med*, vol. 121, p. 103805, Jun. 2020, doi: 10.1016/J.COMPBIOMED.2020.103805.
- [9] A. M. Ismael and A. Şengür, "Deep learning approaches for COVID-19 detection based on chest X-ray images," *Expert Syst Appl*, vol. 164, p. 114054, Feb. 2021, doi: 10.1016/J.ESWA.2020.114054.
- [10] A. Ella Hassanien, V. Snasel, S. M. Elghamrawy, A. Ella Hassanien, and C. Author, "Optimized Deep Learning-Inspired Model for the Diagnosis and Prediction of COVID-19", doi: 10.32604/cmc.2021.014767.
- [11] S. M. JavadiMoghaddam and H. Gholamalnejad, "A novel deep learning based method for COVID-19 detection from CT image," *Biomed Signal Process Control*, vol. 70, p. 102987, Sep. 2021, doi: 10.1016/J.BSPC.2021.102987.

- [12] P. Ghose et al., “Detecting COVID-19 infection status from chest X-ray and CT scan via single transfer learning-driven approach,” *Front Genet*, vol. 13, p. 980338, Sep. 2022, doi: 10.3389/FGENE.2022.980338.
- [13] F. Demir, K. Demir, and A. Şengür, “DeepCov19Net: Automated COVID-19 Disease Detection with a Robust and Effective Technique Deep Learning Approach,” *New Gener Comput*, vol. 40, no. 4, pp. 1053–1075, Dec. 2022, doi: 10.1007/S00354-021-00152-0/TABLES/7.
- [14] I. Chouat, A. Ectioui, R. Khemakhem, W. Zouch, M. Ghorbel, and A. Ben Hamida, “COVID-19 detection in CT and CXR images using deep learning models,” *Biogerontology*, vol. 23, no. 1, pp. 65–84, Feb. 2022, doi: 10.1007/S10522-021-09946-7/TABLES/3.
- [15] A. L. Aswathy, H. S. Anand, and S. S. V. Chandra, “COVID-19 severity detection using machine learning techniques from CT-images,” *Evol Intell*, vol. 16, no. 4, pp. 1423–1431, Aug. 2023, doi: 10.1007/S12065-022-00739-6/TABLES/8.
- [16] O. R. Shahin, R. M. Abd El-Aziz, and A. I. Taloba, “Detection and classification of Covid-19 in CT-lungs screening using machine learning techniques,” *Journal of Interdisciplinary Mathematics*, vol. 25, no. 3, pp. 791–813, Apr. 2022, doi: 10.1080/09720502.2021.2015097.
- [17] A. Kukker and R. Sharma, “JAYA-Optimized Fuzzy Reinforcement Learning Classifier for COVID-19,” *IETE J Res*, vol. 69, no. 10, pp. 7314–7325, Oct. 2023, doi: 10.1080/03772063.2022.2027287.
- [18] F. Bayram and A. Eleyan, “COVID-19 detection on chest radiographs using feature fusion based deep learning,” *Signal Image Video Process*, vol. 16, no. 6, pp. 1455–1462, Sep. 2022, doi: 10.1007/S11760-021-02098-8/TABLES/3.
- [19] L. Martinelli et al., “Face Masks During the COVID-19 Pandemic: A Simple Protection Tool With Many Meanings,” *Front Public Health*, vol. 8, p. 606635, Jan. 2021, doi: 10.3389/FPUBH.2020.606635.
- [20] S. Vaid, R. Kalantar, and M. Bhandari, “Deep learning COVID-19 detection bias: accuracy through artificial intelligence,” *Int Orthop*, vol. 44, no. 8, pp. 1539–1542, Aug. 2020, doi: 10.1007/S00264-020-04609-7/FIGURES/2.
- [21] B. Gülmez, “A novel deep neural network model based Xception and genetic algorithm for detection of COVID-19 from X-ray images,” *Ann Oper Res*, vol. 328, no. 1, pp. 617–641, Sep. 2023, doi: 10.1007/S10479-022-05151-Y/TABLES/17.
- [22] Y. D. Zhang, S. C. Satapathy, X. Zhang, and S. H. Wang, “COVID-19 Diagnosis via DenseNet and Optimization of Transfer Learning Setting,” *Cognit Comput*, vol. 16, no. 4, pp. 1649–1665, Jul. 2024, doi: 10.1007/S12559-020-09776-8/TABLES/13.
- [23] H. Yao et al., “Severity Detection for the Coronavirus Disease 2019 (COVID-19) Patients Using a Machine Learning Model Based on the Blood and Urine Tests,” *Front Cell Dev Biol*, vol. 8, p. 571715, Jul. 2020, doi: 10.3389/FCCELL.2020.00683/BIBTEX.
- [24] K. Balasamy and V. Seethalakshmi, “HCO-RLF: Hybrid classification optimization using recurrent learning and fuzzy for COVID-19 detection on CT images,” *Biomed Signal Process Control*, vol. 100, p. 106951, Feb. 2025, doi: 10.1016/J.BSPC.2024.106951.
- [25] M. Awais, A. Bhuya, D. Bhuya, S. Fatima, and T. Sadiq, “Optimized DEC: An effective cough detection framework using optimal weighted Features-aided deep Ensemble classifier for COVID-19,” *Biomed Signal Process Control*, vol. 86, p. 105026, Sep. 2023, doi: 10.1016/J.BSPC.2023.105026.