Adopting Chest X-Ray and Chest CT Images for the Diagnosis of COVID-19 using Image Processing Techniques: Survey

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Abstract: The presence of COVID-19 infection and its threat to human life has led to the urgent need to contribute to combating it, so global initiatives have emerged to regulate and manage the virus, with the aim of eliminating it once and for all. Since the use of image processing has succeeded in solving many complicated problems in the medical field, it can now be employed to aid in the fight against COVID-19 and control it by extracting the relevant features collected from medical imaging datasets and categorizing using machine learning and deep learning approaches in order to diagnose and predict the COVID-19 disease. This study provides an overview of current findings on machine learning methods that have been applied to COVID-19 and aspects related to the types of algorithms, the medical dataset used, and the accuracy of researchers' results. This paper, review the latest proposed models for COVID-19 classification and diagnosis applied to CT scans and chest X-ray images to provide further insight into disease reduction. COVID-19 diagnosis is critical for identifying an infected person and preventing the virus from spreading. Because diffusion is rapid, an automated rapid diagnostic mechanism is required to deal with a huge population so image processing methods are the most suitable technology for this. These models' accuracy ranged from 80.6% to 100%, demonstrating that image- processing methods can be used to assess and diagnose COVID-19 clinically.

***Keywords*:** COVID-19, Chest X-ray Images (CXR), Chest Computed Tomography (CT), machine learning, CNN, Image processing, Accuracy.

1. Introduction

Governments, health organizations, and researchers around the world are paying attention to the Corona pandemic, which has been considered an international health crisis. As a result, several areas of research, including image processing, social sciences online, data-intensive software, statistical analysis, design automation, and modeling and simulation, have grown exponentially without the need for significant investments in computational equipment. Researchers in a variety of fields and contexts have found these areas of research to be very promising. Researchers in the fields of data science and data analysis are examining health-related data in order to contribute to the development of medical research [1]. COVID-19 afflicted patients have severe inflammation of the bronchioles and cavities, which is produced by the lungs' damage. The information gained from computed tomography (CT), lung ultrasound (US), and x-ray images is necessary for arriving at a correct medical diagnosis. Researchers can provide significant assistance in the assessment of the COVID-19 accessible image datasets and offer logical conclusions that can benefit in the fight against the disease if they use the right technique. Researchers have been able to analyze the available data to provide potential solutions that can help in the treatment and detection of the disease by using a computer and its algorithm, thanks to rapid scientific development and the use of medical data collected by a large number of individuals infected with Corona virus. Advanced computer-aided algorithms can be used in the diagnosis, recognition, and surgical planning of a specific treatment in medical imaging, which is a developing and ongoing subject[2]. In the diagnosis and detection of the COVID-19 study, image processing has been employed in medical research. In order to detect and predict the COVID-19 disease, relevant features are extracted from image datasets and categorized by using machine learning methods, pattern recognition, data mining, and deep learning. Deep learning is currently being employed extensively in the field of medical imaging due to its superior performance over traditional methods which is helped to improve the efficiency of diagnosing the disease by analyzing X-ray images, lung ultrasound (US), and computed tomography (CT)[3].

An overview of the many strategies and models for detecting and diagnosing this disease using image processing technologies is offered in this paper. The survey was organized as follows in section 2. In section 3, the standard medical datasets used are described. The steps of image processing methods have been explained deeply in section 4. The performance of the models was analyzed to see how well the models performed in section5. Discussion and conclusion are included in section 6 and section 7, respectively.

2. Literature Review

Many researchers are working to classify and detect the COVID-19 patient image data using different preprocessing, machine learning, and dataset. Two important datasets are used for classifying: chest X-rays and chest CT images[4]. The literature review in this paper was divided into three phases according to the database used to diagnose COVID-19:

2.1. Subsection Chest X-ray Images (CXR)

There is a wide range of research to diagnose COVID-19 using X-rays dataset, some of them are:

Linda.w, et al. [5] designed a model for the detection of COVID-19 using a deep convolutional neural network (CNN) with pre-trained neural networks (COVID-Net). The model was applied to a dataset containing 13975 images (including three cases: normal, pneumonia, and COVID-19). The model was able to detect the disease with 93.3% accuracy and 91% sensitivity. While **Muhammad.F, et al.**[6] used *a* pre-trained COVID-ResNet with CNN and applied it to a dataset including four cases instead of three cases (normal, bacterial pneumonia, viral pneumonia, and COVID-19) containing 5941 images. This model was compared with the model of Linda in research[5] by applying the previous model [5] to this same dataset, so the accuracy of disease detection was 83.5% and from here it was concluded that Muhammad's model achieved a performance improvement of about 13% over the previous model in research [5] in the detection the COVID-19, where the accuracy was 96.23% with 100% sensitivity.

Oishy.S, et al. [7] suggested assembly using multiple models for COVID-19 detection where two assembly methods were used: decision fusion and feature concatenation to assemble CNN models. CNN is utilized with five pre-trained networks (Xception, DenseNet121, DenseNet201, InceptionV3, and MobileNet) and applied to two datasets. The first dataset is composed of 6264 images divided into three cases (normal, pneumonia, and COVID-19) while the second dataset is composed of 1632 images divided into four cases (normal, bacterial pneumonia, viral pneumonia, and COVID-19). The result of this research was that the model was able to diagnose COVID-19 with an accuracy of 95.85% when applied to the first dataset, and with an accuracy of 89.26% when applied to the second dataset.

Duaa.F, et al.[8] introduced the system that uses three machine learning methods to classify the diseases and detect COVID-19 based on a dataset containing three cases (COVID-19, pneumonia, and normal). This system includes several algorithms: histogram of oriented gradient (HOG) for extraction of the important feature, K-nearest neighbors (KNN), random forest, and support vector machine (SVM) for images classification into the appropriate disease. At last, the research the accuracy of each machine learning method for images classification is calculated; the result is 88.89%, 96.29%, 98.18%, respectively.

Mohamed.L et al.[9] built a system that uses deep transfers learning, Generative Adversarial Networks (GANs), and three pre-trained networks (ResNet18, GoogLeNet, and AlexNet) based on a dataset containing four cases (normal, bacterial pneumonia, viral pneumonia, and COVID-19). Using GAN resulted in 30 times the number of images generated from the original data collection in order to make the proposed system more effective by overcoming the problem of over fitting. Googlenet was chosen as the main deep transfer system, with the highest accuracy reaching 80.6%.

Oluwadare.A et al.[10] suggested a developed model for COVID-19 detection using CNN and three pre-trained networks (SqueezeNet, Googlenet, and Modified Alexnet) that applied to two datasets which have two, and three cases, respectively. This work achieved an accuracy of 98.31% when using three-class datasets (COVID-19, pneumonia, and normal) but the result differed when using two-class datasets (COVID-19, and normal) as it was compared with **Prabira .K et al.** [11] where research [10] had the best accuracy of 100% while the accuracy of research [11] was 95.33% when pre-trained networks ResNet50 used with support vector machine (SVM) instead of CNN for detection.

Khandaker.F, et al.[4]**, Muhammad.U, et al.[12], Alampally.N, et al.[13], Azher.U, et al.[14]** proposed an algorithm for COVID-19 detection depended on a dataset containing only two cases (COVID-19, and normal). CNN was used in research [4][12] but with different architecture resulting in different accuracy are 97.56%, and 98.8% respectively while in research [13] CNN was utilized with five pre-trained networks (Xception, DenseNet121,DenseNet201,InceptionV3, and MobileNet). A comparison was made between the uses of these five pre-trained algorithms, as the research found that the best accuracy of the system when using an InceptionV3 algorithm reaches 94.8%. In research[14], it was also found that the best system's accuracy when employing InceptionV3 algorithm out of three pre-trained networks (VGG16, InceptionV3, MobileNetV2) used with CNN where the accuracy was 98%.

Anis.S, et al.[15] built their model depends on seven pre-trained networks (Xception, Resnet50, DenseNet121, InceptionV3, Inception-ResNet-V2, VGG19, and VGG16) with CNN. This model was applied on the x-ray dataset which has only two cases (Pneumonia, and COVID-19) and contains 7165 images. The accuracy of each pre-trained algorithm was computed and discussed. The result of the research is that the highest accuracy obtained is 99.48% when using the DenseNet121 algorithm.

Lakshay.G, et al.[16] and **Md.A, et al.[17]** proposed a model for COVID-19 detection using CNN. Research[16] used CNN with three pre-trained networks (Restnet50, VGG16, and VGG19) and applied it to a dataset containing three cases (normal, pneumonia bacteria, COVID-19) while research[17] used only the VGG16 network with CNN to classify the disease in to (normal, COVID-19, other diseases) based on combined six binary classifiers for a various chest x-ray dataset. In the previous two studies, the accuracy was 93% when using the VGG16 network, but in research[16], the accuracy reached 98.12% when using the VGG19 network.

Prateek.G, et al.[18] proposed an efficient model to detect the COVID-19 by using many steps for image processing (Laplace filter, Sobel filter, average filter, gamma correction, and adaptive histogram equalization) and CNN with pre-trained networks (Inception-V3) for classification and diagnosis which is applied to a dataset containing three cases (normal, pneumonia bacteria, COVID-19). This model obtains high accuracy of 97.7% and the reason is due to the use of a set of steps (Laplace filter, Sobel filter, average filter, and gamma correction) to process images before diagnosing them by the system.

2.2. Chest Computed Tomography (CT) Images

There is also a wide range of research to diagnose COVID-19 using CT images dataset, including:

Umut.Ö, et al.[19] presented a strong model based on Convolutional Support Vector Machine (CSVM) for classification of the COVID-19. Three-block with different numbers of SVM kernels were included and applied to a dataset including two cases (COVID-19, normal). Experimental results show that the results of this model are better than using CNN with four pre-trained networks (Resnet50, DenseNet121, GoogleNet, and VGG16), with an accuracy of 94.03% compared to 84.35% for CNN with pre-trained networks (Resnet50).

Ahmed.M, et al.[20] proposed an end-to-end semi-supervised COVID-19 detection system applied to two-case datasets (COVID-19, normal). This system is composed of many steps: 1) the spatial features extraction by using the ResNext+ network 2) The spatial features are transformed into spatial-axial features by using Long Short Term Memory (LSTM) 3) Tone mapping and stochastic image enhancement algorithms were utilized to improve the image quality. The accuracy of the experimental results is 81.9%. **Hammam, et al.**[21] designed a model for the detection of COVID-19 using CNN with two pre-trained neural networks (CovidDenseNet and CovidResNet). It was used on the dataset with two cases (COVID-19, normal) the first time, then it was used on the dataset with three cases (COVID-19, normal, and viral pneumonia). The experimental results showed that the highest accuracy was obtained when assembling these two structures, where the accuracy of the model was 93.87% when using two cases and 83.89% when using three cases of the dataset. **Shreya.B, et al.** [22] built an efficient model for predicting the COVID-19 through assembling three standard deep learning mechanisms with three pre-trained networks (Xception, ResNet50, and VGG-16). Through this assembly, the predictive ability of the system applied to the two-case (COVID-19, non-COVID-19) dataset is improved. The result is the model is able to predict with accuracy 98.79%.

Eduardo.J, et al.[23] proposed algorithm to detect COVID-19. This algorithm composed of two parts: feature extraction and classification part. An unsupervised hierarchical cluster, Recursive feature elimination, and Euclidean distance are used to extract feature and segment the lung region (ROC) while 3D neural network model is used to classify the dieses. This algorithm was applied to the two case (COVID-19, non-COVID-19) with an accuracy of 93%.

Chuansheng.Z, et al.[24] proposed a system to detect COVID-19, 3D CT volumes were used to construct a weakly-supervised deep learning-based software system. A pre-trained neural network (UNet) is used to segment the lung region (ROC) for each patient with a short time process is taken just 1.93 seconds while 3D CNN is used to classify the 3D lung segmentation in order to estimate the likelihood of COVID-19 becoming infected. This system was applied to two cases (COVID-19, normal) and achieved an accuracy of 95.9%.

Sakthi.J, et al. [25] and **Seyed.M, et al.**[26] applied their model to the two-case datasets (COVID-19, normal) but with two different structures. Hybrid multi-layer perceptron with CNN proposed in research[25] to determine the infection of COVID-19 where a multi-layer perceptron is used for classifying dataset and CNN used for extraction the feature. According to the findings, the hybrid technique outperformed the multi-layer perceptron or CNN alone, with an accuracy of 94.89% compared to 80.77% and 86.95% for MLP and CNN, respectively. While a different method was used in research[26], knn was combined with CNN and a pre-trained network (DenseNet201) to achieve the greatest accuracy of 100%.

Mucahid.B, et al. [27] and **Esraa.H, et al.**[28] relied on the classification of corona disease on SVM and two-case datasets (COVID-19, normal). During the classification procedure, 10-fold, 5-fold, and 2-fold cross-validation were used in the research [27]. Grey Level Run Length Matrix (GLRLM), Grey-Level Size Zone Matrix (GLSZM), Discrete Wavelet Transform (DWT) algorithms, Grey Level Co-occurrence Matrix (GLCM), and Local

Directional Pattern (LDP) were used to extract images features where the GLSZM feature extractor achieved the highest accuracy of 98.77%. while in the research [28] three pre-trained networks (VGG 19, VGG 16, Resnet 50, and Inception-V3) used with SVM for classification and diagnosis. The result was the highest accuracy obtained is 98.86% when using the Resnet50 algorithm.

2.3. Chest X-ray and CT images There is a few numbers of researches to diagnose COVID-19 using both x-ray and CT images dataset, including:

Harsh.R, et al.[29] have built a rapid COVID-19 diagnosis model that takes less than three seconds to detect an infected person by using CNN and color visualization based on grad-CAM with pre-trained networks (VGG19) which was used on the dataset with three cases (COVID-19, normal, and pneumonia), where the accuracy obtained in this model is 95.61% accuracy. **Saban.Ö, et al.**[30] proposed a model to detect COVID-19 in the unbalanced and insufficient dataset which has six classes (streptococcus, Sars, pneumocystis-pneumonia, No finding, COVID, and ARds). This model contains many phases: 1) increasing the dataset through applying rotate and scale images. 2) combining many stages of feature extraction (segmentation-based fractal texture analysis (SFTA), gray level run length matrix (GLRLM), local binary gray level co-occurrence matrix (LBGLCM), and gray level co-occurrence matrix (GLCM)). 3) using SMOTE method for oversampling. 4) feature reduction by using PCA and SAE method and getting shrunken features. 5) SVM for classifying shrunken features. The result of this model is that shrunken features with PCA outperform shrunken features with SAE with an accuracy of 71.92% and 94.23%, respectively.

Debabrata.S, et al.[31] introduced a system that uses three machine learning methods to classify the diseases and detect COVID-19 (CNN with pre-trained networks (Inception-V3), CNN with pre-trained networks (VGG-16), and decision tree) applied to a dataset containing two cases (COVID-19, normal). The three models were compared, the decision tree and Inception-V3 showing lower performance with an accuracy of 60% and 78%, while VGG-16 provides very satisfactory results with an accuracy of 91%. **Amr.A** [32] presented two flexible models to diagnose COVID-19 using multiple machine learning approaches (Random Forest, K-nearest neighbor, Multi-layer Perceptron, and support vector machine) which were applied to two-case datasets (COVID-19, normal). The first model is for the CT scan dataset while the second is for the x-ray dataset. Each model contains many processes: 1) extracting features by using threshold adjacency statistics, Haralick texture features, HSV color histograms, and raw pixel intensities. 2) machine learning approaches 3) voting classifier of best performing model. These models efficiently work with an accuracy of 98.2% when are given CT images and 99.6% when are given x-ray images. **Halgurd.S, et al.** [33]applied their model to the two-case datasets (COVID-19, normal) by using a modified pre-trained neural network (AlexNet) with CNN. The accuracy of the modified CNN is 94.1%, whereas the accuracy of the pre-trained network is 98%, according to the study. **Vinayakumar.R, et al.**[34] presented a powerful model to detect COVID-19 using a meta-classifier technique based on deep learning with pre-trained networks (EfficientNet). This model is composed of two phases: 1) predication phase by using SVM and random forest. 2) classifying the dataset into either non-COVID-19 or COVID-19 by using a logistic regression classifier. The result shows that this work is better than CNN-pre-trained models with an accuracy of 99%.

3. Standard Medical Imaging Dataset Acquisition

Finding a suitable dataset for the COVID-19 virus is difficult because it was only recently discovered. Two publicly available datasets are used in this study, chest X-ray images and chest computed tomography (CT). These datasets are generally obtained from two open-source repositories, Kaggle and GitHub repository which can include two cases or three cases, or four cases. Figure 1 is an example of a standard medical dataset that is composed of two cases where those who are not infected with COVID-19 are negative, while the patients who are infected with COVID-19 are positive [32]. Because it is readily available and less expensive, the chest X-Ray is preferred for imaging when compared with a CT scan; a CT scan of the chest produces a more detailed and improved image. Muscles, organs, bones, and Fats are all shown in the scans, allowing physicians to make precise diagnoses[35].

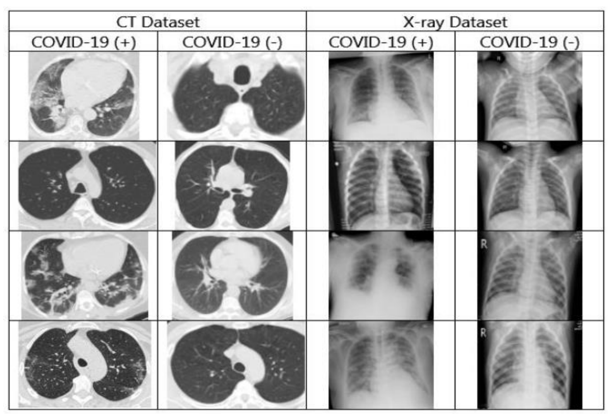

Fig. (1): Standard Medical Imaging Dataset, where the symbol (+) means positive and the symbol (-) means negative[32].

4. Image Processing Methods

Image processing techniques are an important element of today's computer technology. They are used in a various applications such as computer vision, video surveillance, object detection, and the medical industry, among others[36]. It contains a set of steps shown in Figure2

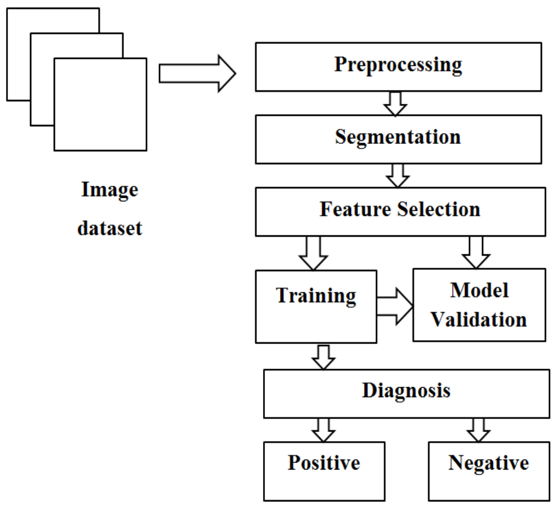

Fig. (2): Image processing steps for COVID-19 detection.

4.1. Preprocessing

It is the initial step in image processing. After obtaining the images from the standard medical imaging dataset, the step preprocessing begins through a set of filters to convert the color image to gray, remove noise and delete text, making it clear and free of distortion and suitable for the next step[37].

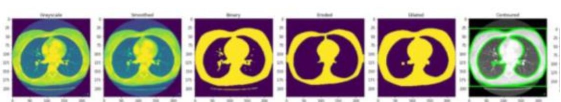

Fig. (3): Applying several preprocessing steps to a chest CT image[38]

4.2. Image Segmentation

It is an important process of image processing to simplify the representation of an image and facilitate its analysis by dividing it into different small parts called segments. There are numerous techniques for image segmentation depending on pixel features[39]. The purpose of segmentation is to define the region of interest. In the scan, lungs, lobes, and infected lesions are seen. To extract features, the segmented ROI is employed[35]. A segmented image and its original form can be seen in Figure 4.

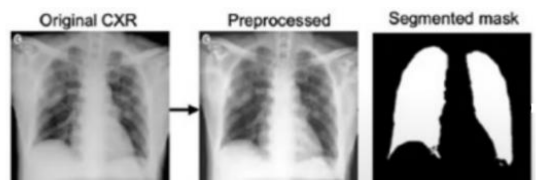

Fig. (4): Application of one of the segmentation methods to a chest x-ray image[40]

4.3. Feature Selection

In raw data representation, feature selection is critical because the primary objective of this step is to extract highly discriminated features from raw data that can improve the classifier's classification accuracy so it is considered one of the most popular research topics in the field of machine learning and computer vision. As the number of data sets grows larger, numerous data dimensionality reduction approaches are developed to improve the performance of classification systems and data mining[41].

4.4. Diagnostic

One of the machine learning algorithms uses to diagnose COVID-19 like Genetic Algorithms, Fuzzy Logic, Support Vector Machines, Artificial Neural Networks, Deep Convolutional Neural Network etc.[37] It is used to classify the dataset by training and testing into infected with covid-19 and uninfected with covid-19 as shown in figure 5.

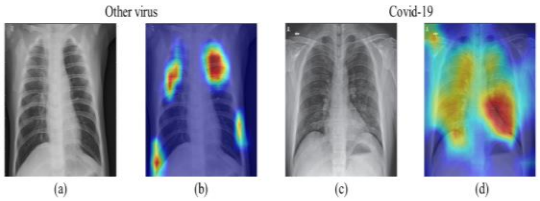

Fig. (5): Diagnostic result in chest x-ray dataset, the original image is (a) (c), (d) result is positive (infected with COVID-19), (b) result is negative (infected with another virus)[11]

5. Evaluate the performance of the models

In order to assess the models' performance for their ability to diagnose the COVID-19, their accuracy, True Negative Rate (Specificity), and True Positive Rate (Sensitivity), F1 score (F-Measure) were determined[42]. The number of correct predictions divided by the total number of input chest X-ray and chest CT images sample is referred to as accuracy. The fraction of correctly predicted negatives divided by the total number of negatives is known as specificity. The ratio of appropriately considered positive data points to all positive data points is known as sensitivity[10]. The scale is calculated as the harmonic mean from specificity and sensitivity by means is called the F1 score[43]. The equations for evaluating the model are shown below:

$$\text{Accuracy} = \frac{\text{all correct}}{\text{all samples}} \times 100\% \quad (1)$$

$$\text{Specificity} = \frac{true\ Negative}{all\ Negative} \quad (2)$$

$$\text{Sensitivity} = \frac{True\ positive}{all\ Positive} \quad (3)$$

$$\text{F1 score} = 2 \times \frac{\text{Specificity} \times \text{Sensitivity}}{\text{Specificity} + \text{Sensitivity}} \quad (4)$$

6. Discussion

Some recent exemplary studies in Google Scholar, Springer, IEEE Xplore, and Scopus databases that give a general idea of their efficacy have been selected to describe the method and performance of image processing-based COVID-19 diagnosis. They used a variety of data sets and image preprocessing, as well as several performance indicators.

This paper provides an overview of 32 articles that are divided according to the dataset into three sections: (Described in detail in Table 1)

- The x-ray dataset has been applied to 16 articles, with the following results:
- There are seven articles that use two-case datasets (normal and COVID-19), five articles that use three-case datasets (normal, pneumonia, and COVID-19), two articles that use four-case datasets (normal, bacterial pneumonia, viral pneumonia, COVID-19), and two articles that use two types of dataset.

- There are fourteen articles that depend on CNN and pre-trained networks while the others depend on SVM.
- There are five articles applied to a limited number of datasets.
- The accuracy of these 16 articles ranged from 80.6% to 100%.
- The CT scan dataset has been applied to 10 articles, with the following results:
- There are nine articles that use two-case datasets (normal and COVID-19), and one articles that use two types of dataset.
- They used different methods for detection.
- There is one article applied to a limited number of datasets.
- The accuracy of these 10 articles ranged from 81.9% to 100%.
- The x-ray and CT scan datasets have been applied to 6 articles, with the following results:
- There are four articles that use two-case datasets (normal and COVID-19), one article that uses Six cases (COVID, Sars, pneumocystis-pneumonia, No finding, ARds, and streptococcus), and one article that uses three case datasets (normal, pneumonia, and COVID-19).
- There are three articles that depend on CNN and pre-trained networks while the others depend on different methods.
- There are three articles applied to a limited number of datasets.
- The accuracy of these 6 articles ranged from 82% to 99.6%.

Table 1: Literature Review for X-ray and CT based COVID-19 Diagnosis (Accu.: accuracy, Sens.: sensitivity, Rec.: recall, Spec.: specificity)

Author, year	**Comparable between Literature Review**						
	Dataset description	***Image processing***	***Method***	***Evaluate the models' performance***			
				Accu	***Sens Rec***	***Spec***	***F1 score***
Linda et al.[5] (2020)	- X-ray images - Three cases: normal, pneumonia, and COVID-19 -13975 images	- Convert image from (480×480×3) to (240×240×56)	- CNN with COVID-Net - Convolutions3×3 - Number of epochs=22 - learning rate = 1e-4	93.3%	91%	-	-
Muhammad.F, et al. [6] (2020)	- X-ray images - Four cases (normal, bacterial pneumonia, viral pneumonia,and COVID-19) - 5941 images	- All images resized to 128x128x3	- CNN with COVID- ResNet - Number of layers=50 - Number of epochs=25 - learning rate = 1e-6	96.23 % Better than Linda by about 13%	100 %	-	100%
Oishy.S et al. [7] (2020)	- X-ray images - Three cases (normal, pneumonia, COVID-19) - 6264 images	- images are resampled to a uniform size	- two assembly methods: decision fusion and feature concatenation to assemble CNN models Xception, DenseNet121, DenseNet201, InceptionV3, and	95.84 %	95.83%	97.9 %	95.83 %

Comparable between Literature Review

Author, year	*Dataset description*	*Image processing*	*Method*	*Evaluate the models' performance* *Accu*	 *Sens Rec*	 *Spec*	 *F1 score*
	- Four cases (normal, bacterial pneumonia, viral pneumonia, COVID-19) -1632 images		MobileNet - Number of layers=2 - Number of epochs=50 - learning rate = 1e-5	89.26 %	89.27%	95.59%	88.72 %
Duaa.F, et al.[8] (2020)	- X-ray images - Three cases (normal, pneumonia, COVID-19) - 520 images	- histogram of oriented gradient (HOG) for extraction of the important feature - All images resized to 64 × 128 pixls	- K-nearest neighbors (KNN), random forest, and support vector machine (SVM) - 80% training, 20% testing	98.18 % the best classification algorithm is SVM	95%	-	95%
Mohamed.L et al [9] (2020)	- X-ray images - Four cases (normal, bacterial pneumonia, viral pneumonia,and COVID-19) - 307 images	- Generative Adversarial Networks (GANs) to increase the dataset to 8100 images instead of 307 images	- deep transfers learning, (ResNet18, GoogLeNet, and AlexNet) - 80% training, 20% testing - Number of filters=64	80.6% the best pre-trained algorithm is the GoogLeNet algorithm	80.56%	-	82.32 %
Oluwadare.A et al [10] (2020)	- X-ray images - Two cases (normal, COVID-19) - 789 images - Three cases (normal, pneumonia, COVID-19) - 1188 images	- adaptive filtering technique to romove the noise and image contrast enhanced using histogram equalization - flipping the images to 270, 160, and 70 degrees - rotating the images to right and left to prevent overfiting	- CNN with (SqueezeNet, Googlenet, and Modified Alexnet) - 60% training, 20% validation, 20% testing - Number of epochs=6 - learning rate = 1e-4	100% 98.31 % the best pre-trained algorithm is the Alexnet algorithm	100 % 98.55 %	100 % 99.37 %	- -
Prabira.K et al[11] (2020)	- Three cases (normal, pneumonia, COVID-19) - 1188 images	- histogram of oriented gradient (HOG) for feature extraction	- ResNet50 with SVM - 80% training, 20% testing	95.33 %	95.33%	-	95.34 %
Khandaker.F, et al. [4] (2020)	- X-ray images - Two cases (normal, COVID-19) - 5863 images	- All images resized to 224x224x3	- CNN - 80% training, 20% testing - Number of layers=5 - Convolutions3×3 - Number of epochs=25 - learning rate = 1e-4	97.56 %	100 %	-	97.61 %
Muhammad.U, et al.**[12]** (2020)	- X-ray images - Two cases (normal, COVID-19) - 738 images	- remove duplicates images - use filters to remove features - resized image to 198 x 198 x 32	- CNN - 70% training, 30% testing - Number of layers=4 - Convolutions3×3 - Number of epochs=70	98.0 %	-	-	-
Umut.Ö, et al.[19] (2020)	- CT images - Two cases (normal, COVID-19) - 2492 images	- Images normalization and resizing	- CSVM - 75% training, 25% testing - convolution filters (7 × 7), (3 × 3), and (1 × 1)	94.03 %	96.06%	92.01%	94.10 %
Ahmed. M, et al.[20] **(2020)**	- CT images - Two cases (normal, COVID-19) - 22873 images	-Long Short Term Memory (LSTM) - Tone mapping and stochastic image enhancement algorithms	- semi-supervised with ResNext+ network - 80% training, 20% testing	81.9%	-	-	81.4 %
Eduardo.J, et al.[23]	- CT images - Two cases (normal, COVID-19)	- An unsupervised hierarchical cluster, Recursive feature	- 3D neural network - Convolutions 1×3×3	93%	90%	83%	-

Author, year	Dataset description	Image processing	Method	Evaluate the models' performance: Accu	Sens Rec	Spec	F1 score
			Comparable between Literature Review				
(2020)	- 2446 images	elimination, and Euclidean distance are used to extract feature and segment the lung region (ROC)					
Chuansheng.Z, et al.[24] (2020)	- CT images - Two cases (normal, COVID-19) - 360 images	- normalized the image from 16-bit to 8-bit - resampled CT-Mask volumeto a specific spatial resolution (224×336)	- weakly-supervised deep learning with (UNet) - learning rate = 1e-5	95.9%	90.7 %	91.1 %	-
Harsh. R, et al.[29] **(202o)**	- CT images and x-ray images - Three cases (COVID-19, normal, and pneumonia) - 2482 CT images - 6529 x-ray images	-Images normalization and resizing	- CNN and color visualization based on grad-CAM with (VGG19) - 80% training, 20% testing	95.61 %	95%	-	97%
Saban. Ö, et al.[30] **(2020)**	- CT images and x-ray images - Six cases (COVID, Sars, pneumocystis-pneumonia, No finding, ARds, and streptococcus) - 126 images	- increasing to 260 the dataset through applying rotate and scale images - feature reduction by using PCA and SAE method - SMOTE method for oversampling to 495.	- Combining (SFTA, GLRLM, LBGLCM, and GLCM) - PCA and SAE method -SVM	94.23 % The best result when used shrunken features with PCA	91.88%	98.54%	93.99 %
Debabrata.S, et al.[31] **(2020)**	- CT images and x-ray images - Two cases (normal, COVID-19) - 360 images	- Using a feature detection Kernel to reduce noise	- CNN with (Inception-V3), CNN with (VGG-16), and decision tree	91% the best algorithm is the VGG16 algorithm	94%	-	93%
Lakshay .G, et al. **[16]** (2020)	- X-ray images - Three cases (normal, pneumonia bacteria, COVID-19) - 748 images	- images are resampled to a uniform size	- CNN with (Resnet50, VGG19, and VGG16) - 75% training, 25% testing - convolutional layers =16 - Number of epochs=50	98.12 % the best pre-trained algorithm is the VGG19 algorithm	-	-	-
Mucahid.B, et al. [27] (2020)	- CT images - Two cases (normal, COVID-19) - 15660 images	- GLRLM, GLSZM, DWT, GLCM, and LDP were used to extract images features	- used 10-fold, 5-fold, and 2-fold cross-validation. - Sample images spilt into four subsets 64x64, 48x48, 32x32, 16x16	98.77 % GLSZM feature extractor achieved the highest accuracy.	97.72 %	99.67%	98.65 %
Alampally.N, et al.**[13]** (2021)	- X-ray images - Two cases (normal, COVID-19) -10500 images	-Images normalization Data Labeling	- CNN with (Xception, DenseNet121, DenseNet201, InceptionV3, and MobileNet) - 80% training, 20% testing -Number of epochs=500 - learning rate = 1e-5	94.8% the best pre-trained algorithm is the InceptionV3 algorithm	96%	-	96%
Azher.U , et al. **[14]** (2021)	- X-ray images - Two cases (normal, COVID-19) - 2541 images	- Features extraction using filter size 32	- CNN with (VGG16, InceptionV3, and MobileNetV2) - 75% training, 25% testing - Number of epochs more than 10	98% the best pre-trained algorithm is the InceptionV3 algorithm	100 %	-	99%

Comparable between Literature Review

Author, year	*Dataset description*	*Image processing*	*Method*	*Evaluate the models' performance* *Accu*	*Sens Rec*	*Spec*	*F1 score*
Anis.S,et al. **[15]** (2021)	- X-ray images - Two cases (Pneumonia, COVID-19) - 7165 images	- Images normalization and resizing	- CNN with (Xception, Resnet50, DenseNet121, InceptionV3, Inception-ResNet-V2, VGG19, and VGG16) - Number of epochs=20 - learning rate = 1e-3	99.48% the best pre-trained algorithm is the DenseNet121 algorithm	99.48%	-	99.49%
Hammam, et al.[21] (2021)	- CT images - Two cases (normal, COVID-19) - 1083images	- resizing images - using canvas with a spatial dimension of 253×349	- CNN with (CovidDenseNet and CovidResNet) - 60% training, 15% validation, 25% testing - Number of epochs=100 - learning rate = 0.0003	93.87%	92.49%	97.73%	95.70%
	- Three cases (normal, pneumonia, COVID-19) - 4383 images			83.89%	82.04%	92.07%	81.05%
Md.A, et al**[17]** (2021)	- X-ray images - based on six binary classifiers grouped to classify them into (normal, COVID-19, other diseases) - 1728 images	- resized images to 224x224 pixel	- CNN with (VGG16) - 80% training, 20% testing	93%	87%	94%	93%
Prateek. G, et al**[18]** (2021)	- X-ray images - Three cases (normal, pneumonia bacteria, COVID-19) - 33976 images	- resized images to 224x224 pixel - Laplace filter and Sobel filter to enhance an image. - for smoothing, average filter and gamma correction - adaptive histogram equalization for improving image contrast	- CNN with (Inception-V3) - 80% training, 20% testing - Number of epochs=50	97.7%	95%	-	96%
Shreya, **et al.** [22] (2021)	- CT images - Two cases (normal, COVID-19) - 2482 images	- avoid overfitting through batch normalization and dropout	- assembling three DL with (Xception, ResNet50, and VGG-16) - 80% training, 20% testing - Convolutions3×3	98.79%	98.79%	-	98.79%
Amr.A [32] **(2021)**	- CT images - Two cases (normal, COVID-19) - 2471images	- extracting features by using threshold adjacency statistics, Haralick texture features, HSV color histograms, and raw pixel intensities	- Random Forest, K-nearest neighbor, Multi-layer Perceptron, and support vector machine - 80% training, 20% testing	98.2%	97.98%	98.38%	-
	- X-ray images - 1227 images			99.6%	100%	99.24%	-
Halgurd.S, et al. [33] **(2021)**	- CT images - Two cases (normal, COVID-19) - 361images	- resizing the images - cropping with 227 widths and 227 height	- CNN with (AlexNet). - 50% training, 50% validation - Number of epochs=20 - learning rate = 3e-4	98%	100%	96%	-
	- X-ray images - 170 images			82%	72%	100%	-
Vinayakumar. R, et al.[34] **(2021)**	- CT images - Two cases (normal, COVID-19) - 8055 images - X-ray images	- normalization - resized the images	- meta-classifier with (EfficientNet). - SVM and random forest - a logistic regression classifier - 70% training, 30% testing	99%	99%	-	99%

Author, year	**Comparable between Literature Review**			**Evaluate the models' performance**			
	Dataset description	***Image processing***	***Method***	***Accu***	***Sens Rec***	***Spec***	***F1 score***
	- 9544 images						
Sakthi. J, et al. [25] (2021)	- CT images - Two cases (normal, COVID-19) - 1200 images	- removing the fully linked layers from the CNN model and extracting features.	-Hybrid multi-layer perceptron with CNN - 80% training, 20% testing	94.89 %	93%	95%	94%
Seyed. M, et al. [26] **(2021)**	- CT images - Two cases (normal, COVID-19) - 2740 images	- resized images to 224x224 pixel - convert grey image to RGB	- knn and CNN with (DenseNet201) - Convolutions3×3	100%	100 %	100 %	100%
Esraa. H, et al.[28] **(2022)**	- CT images - Two cases (normal, COVID-19) - 13413 images	- resized images to 224x224×3 - used different processing techniques: flips shear, shifts, and random rotation.	- SVM with (VGG 19, VGG 16, Resnet 50, and Inception-V3)	98.96 % the best pre-trained algorithm is the Resnet50 algorithm	99.33%	98.60%	98.95 %

7. Conclusion

We offered a comprehensive overview of image processing techniques and strategies to counteract the COVID-19 epidemic in this study, by detecting and diagnosing it in patients to limit the spread of the disease. The described methods that were used for detecting and classification COVID-19 were divided into three parts according to the database: X-ray Images, (and CT) scans, and using both of them together.

In this study, (32) articles were presented, where 16 of them were applied to an x-ray dataset, 10 of them were applied to the CT scan dataset, and the rest were applied to both types of datasets. They used different methods for detecting COVID-19. A lot of articles used CNN and pre-trained networks for classifying the disease. These models' accuracy ranged from 80.6% to 100%. In this paper, it was concluded that to make the suggested model clinically practical, the model must be trained on a huge dataset comprising a variety of X-ray images and CT scans not currently available to the public. Where it is useful to apply the model to a huge dataset because the larger the dataset, the more insights we can derive from this data as well as the accuracy of the model will be improved, thus trust in the model will increase and allow it to generalize well. Finally, we think that such efforts will have a far-reaching influence with favorable outcomes for periods of the COVID-19 epidemic, so we've included detailed summaries of recent works on the diagnosis of COVID-19, as well as available resources to support further the researchers and develop their own ideas.

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