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Review Article

Exploring Chest Disease Classification Methods Using X-ray Image Analysis

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Abstract

The World Health Organization has suffered from the limited diagnosis support systems and limited physicians. Especially in rural areas, almost all cases are handled by a single physician that is time consuming and tiring. Computer added diagnostic systems are being developed to solve this problem. The automated computer added diagnostic tools are of great significance for patient screening. The computer-aided detection based on Chest X-Ray Radiographs (CXR) play an important role in the diagnosis and treatment planning of the patients having lung diseases such as COVID-19, pneumonia etc. This review article presents a brief overview of all the available computer-aided systems to classify chest diseases using X-ray images. This review emphases the most common chest diseases such as Covid-19 and pneumonia along with different deep learning and machine learning techniques as available in the literature. This review paper can be useful for the researchers who are working in these areas for further improvements and advancements in the current technologies.

Keywords: Deep Learning; Chest X-ray Images; Image Classification; Radiology; Pneumonia; COVID-19.

Introduction

Chest diseases including pneumonia and COVID-19, which kill millions of people because they are not detected in time. For the diagnosis of disorders of the chest, a chest X-ray is thought to be the most suitable imaging modality. It takes time to accurately diagnose chest conditions with a chest radiograph. For the purpose of manually diagnosing chest disorders such pneumonia and Covid-19, a radiologists' experience is crucial. Consequently, it is difficult to diagnose chest disorders only from a chest radiograph. As a result, it is believed that computer-aided diagnosis will progress to assist radiologists in identifying regions of interest as well as positive or negative cases of Covid-19 and pneumonia. Techniques for machine learning and deep learning have proven to be effective for medical aided diagnosis. All of these strategies are helpful, but only if they can achieve an accuracy level that is comparable to that of a human. As previously indicated, chest X-rays can be utilized to identify pneumonia. Because of COVID-19, pneumonia is severe. It has a huge, fast effect on the lungs. The primary distinction between COVID-19-caused pneumonia and conventional pneumonia is that the former damages only a portion of the lungs, whilst the latter affects the entire respiratory system.

By listing the available deep learning technologies, highlighting the challenges, and outlining the essential future research, the research contributions were investigated.

Chest X-ray radiography is used more frequently in clinical practice despite CT's superior sensitivity in detection. Its benefits are inexpensive, radiation-dose-minimum, easy to use, and widely accessible in community or general hospitals. Figure 1 provides examples of chest X-ray images of both COVID and non-COVID cases.

Manually diagnosing of this disease is time-taking, vulnerable to human error, and crucially necessitates the assistance of radiologists. It is imperative to consult a highly skilled radiologist because, as Figure 2 shows that anomalies identified in the early stages of COVID-19 may be similar to those observed in certain other pulmonary syndromes, including Viral Pneumonia (VP) and SARS-CoV-2.

Correct interpretation of imaging results can be difficult due to the rapid onset of the disease and similarities to other respiratory conditions including pneumonia Any automated system aimed at diagnosing COVID-19 should consider other respiratory problems for a more comprehensive and accurate diagnosis. Pneumonia can arise from an infection of the lungs caused by the novel coronavirus-related disease COVID-19. Figure 2 illustrates several forms of pneumonia.

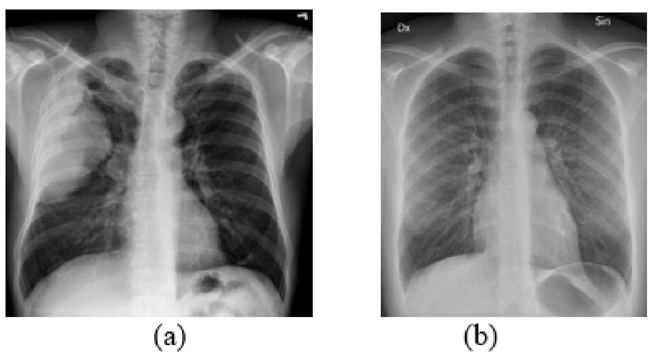

Figure 1: Chest X-ray image of (a) COVID-19 patient and (b) Normal patient.

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Table 1: Publicly available CXR datasets.

Dataset	Size	Classes	Ref.
COVID Chest X-ray	686 images	Positive COVID-19	[35]
COVID-19 Chest X-ray	53 images	Positive COVID-19	[36]
COVID-19-Radiography database	21,173 images	Normal, positive COVID-19, opacity, and viral pneumonia	[34]
Paediatric-CXR [b]	5856 images	Normal, bacterial-pneumonia, viral- pneumonia	[37]
Pneumonia CXR	2356 images	viral- pneumonia	[38]

The Following are the Main Contributions of the Study:

- Table 1 provides an overview of the widely used COVID-19, pneumonia datasets that are openly accessible.
- It gives a summary of the various popular Deep Learning based approaches that have been applied in relevant studies.
- It describes in detail how well the various Deep Learning models perform.

This work aims to identify COVID-19, pneumonia from chest X-ray images with reduced computational power requirements, increased accuracy, and quick processing times.

Detection of Covid-19 using Deep Learning

Various methods for COVID-19 identification with deep learning and chest radiography images have been suggested. This section goes over the suggested techniques for detecting COVID-19 in chest X-ray images. Additionally, as seen in Figure 2, we offer a categorization of several deep learning approaches used to identify COVID-19 diseases in chest X-ray images. As per the reviewed articles, we discovered that training from scratch and transfer learning are the two primary methods used for COVID-19 detection utilizing chest X-ray images. While some methods used chest X-ray datasets to optimize the deep learning models for COVID-19 detection training, other methods applied classification techniques such as Support Vector Machine (SVM) for transfer learning using the features extracted from the taught models. In some respects, multiple deep learning models were developed to detect COVID-19, while others were trained with one CNN model from scratch.

Transfer Learning-based Methods: There are two types of transfer learning approaches: 1) Methods that rely on fine-tuning; 2) Features extraction techniques followed by classification techniques. This section reviews methods that employed X-ray images of chest and used transfer learning to localize COVID-19. We discuss feature extraction-based classification techniques after reviewing Strategies based on positive change.

A) **Fine-Tuning Based Methods:** The optimization method involves importing knowledge from another domain and loading into a deep learning model for a particular task, this method uses learning models to optimize small registered data sets [12]. A few methods have adjusted the training models on chest X-ray images using commercially available neural networks. For the purpose of leveraging chest X-ray images for COVID-19 early detection, a transfer learning strategy utilizing a pre-trained deep learning model on ImageNet was proposed in [13].

B) **Features Extraction:** This section reviews studies using classification methods to diagnose COPD by extracting deep features or common symptoms from chest X-ray images. The deep features that were extracted were from both conventional features like co-occurrence matrix features and ImageNet-based pretrained deep learning models. The suggested techniques to identify COVID-19 utilizing characteristics taken from chest X-ray images are described in the ensuing paragraphs.

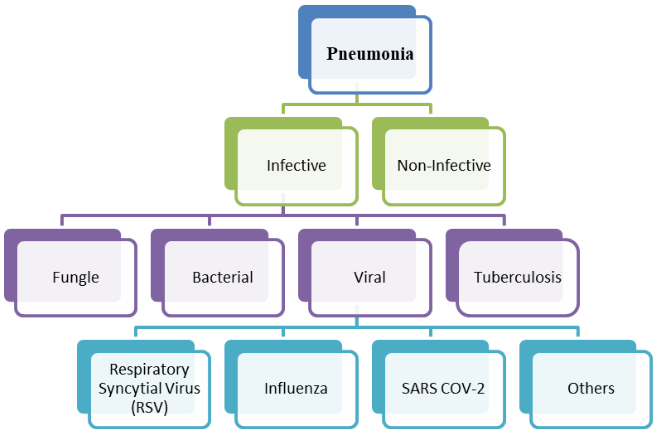

Figure 2: Pneumonia types identified from CXR images [31].

Training from scratch: Reviews studies that described deep learning methods employing datasets of chest X-ray images that were trained from scratch for COVID-19 identification. As explained in the next subsections, single-model-based methods and multi-model-based methods are two groups into which these methods can be separated.

A) **Single model-based methods:** In this approach, a single model-based Convolutional Neural Network was trained on chest X-ray images in order to detect COVID-19. In [14], a straightforward architecture with two convolution layers was created, trained, and displayed. Three public datasets provided data for this neural network's training: 1) The Joeseph Paul dataset, which includes 262 patients' 542 chest X-ray images [15]. 2) COVID-19 dataset developed at Qatar University by researchers [16,18]. 3) The Kermany et al. dataset [17].

B) **Multiple model-based methods:** The following paragraph provides more information on the several model-based techniques that are discussed in this chapter. These techniques integrate and train multiple deep learning models to identify COVID-19 from chest X-ray images. In [19], an autoencoder and a convolutional neural network were trained, with the autoencoder's latent space serving as the convolutional neural network's input. Using a dataset of chest X-ray images that included 400 positive cases of COVID-19 and normal cases is 400, this technique outperforms a VGG16 model by 2% [15]. A different approach is presented in [20] that uses chest X-ray images datasets to train ResNet50v2 and Xception networks for COVID detection and feature learning.

Literature Survey

We analyze CXR images showing signs of Viral infections with SARS-CoV-2 using DL techniques. Key research papers to implement transfer learning using data sets of CNN architectures trained on ImageNet. The sections below provide an overview of the CNN method for COPD detection and the data analyze for this study.

A CNN-based Model for COVID-19 Forecasting

A model was created for preprocessing and classifying a given chest X-ray picture using CNN architectures that have already been trained. Selecting the best preprocessing enhancement processes for optimal performance improvement requires a thorough understanding of the issue, data collection, and production environment COVID-19 diagnosis system based on Deep Learning, with defined steps to go including the later below.

Preprocessing: Preprocessing is required to improve the image quality and, in turn, the performance of the model. It needs to be resized, normalized, and sometimes converted to grayscale. Image preprocessing is the process of formatting images before using them for inference and model training. This preprocessing stage would be applied to images used in testing and training. In order to prepare image data for model input, preprocessing is required. In CNN systems, normalization and picture scaling are essential steps that maintain image stability and enhance model performance. A Convolutional Neural Network learns faster and the gradient descent is more stable when normalization is applied. Histogram equalization is an alternative image processing technique that uses image intensity histograms to enhance the global contrast of images, such as those found in Heidari et al. [10]. Shear is a type of image distortion that can be used to improve photos for computer vision applications, such as those found in Khan et al. [11], or to create or correct perspective angles.

The reason of resizing images is to maintain consistency, and resizing ensures that all input images are of the same size, which is essential for stable model training and inference. By resizing, strike a balance between computational cost and preserving the spatial features that a CNN can effectively learn.

This section provides a description of the preprocessing methods used in our studies. The various preprocessing methods utilized in our studies are listed in Table 2.

Traditional CNN Architecture: These days, CNN architectures can perform at an expert level on par with humans in a number of challenging visual tasks, including pathology identification and medical picture processing. There have been several different CNN designs put forth in the literature since the first effective CNN was created in 1998. It was referred to as LeNet and was extensively utilized for the handwritten digit recognition application. The developer of it was Yann LeCun. LeNet is a shallow design compared to existing models, with three convolutional, two averages pooling, and two fully connected layers. For feature extraction, CNN is utilized. an outline of a standard Convolutional Neural Network for COVID-19 prediction, which is explained in more detail below.

1. Input Layer: The input layer represents the starting point of the model. It takes the raw data (images, text, etc.) and passes it on to the next layers. For image data, this layer usually takes input in the form of a 3D array: height × width × channels (e.g., 256x256x3 for a colour image).

2. Batch Normalization: Normalizes the input to a layer by scaling and shifting, which helps improve training stability and speed.

3. Convolutional Layer: The convolutional layer is created by convolving learnable filters, frequently referred to as kernels, with the input images. The method is an element-wise point product and a sum to generate a number as a feature map element.

Table 2: Several methods for preparing Chest-X-ray images.

Names of Author	Year	Methods of image preprocessing
Heidari et al. (2020) [22]	2020	Histogram equalization technique, bilateral low-pass filter, and image scaling of 224 by 224 pixels
Jain et al. (2020) [23]	2020	640 by 640 pixels is the new size of the image. Gaussian blur and rotation as augmentation techniques
Khan et al. (2022) [24]	2022	Techniques for augmentation: rotation, shear, reflections in both horizontal and vertical planes The resolution of each image was lowered to 224 * 224 * 3.
Islam et al. (2020) [25]	2020	The image has been resized to 224 by 224 pixels.
Sousa et al. (2022) [26]	2022	Image augmentation involving zoom, breadth, height, flipping horizontally and vertically, range rotation, and resizing the input from 200 * 200 to 300 * 300
Abbas et al. (2021) [27]	2021	Select five additional random angles for translation, rotation, rotation up, rotation down, and right/left. Histogram transformation
Gupta et al. (2022) [28]	2022	Resize the image to 128*128*3 pixels
Asnaoui and Chawki (2021) [29]	2021	Normalization of energy levels Finite difference adaptive histogram equalization Using geometric transformations (such as rescaling, rotating, shifting, shearing, zooming, and flipping) as methods for enhancement Image scaled to 299 * 299 pixels for Inception Resnet V2.
Jia et al. (2021) [30]	2021	Reduced image size to 299 x 299 x 3 for mobileNet adaptation Images resized with the Modified ResNet to 256 x 256 x 3.

4. Pooling Layer: Pooling layer Convolutional networks can have both the basic convolutional layers and local and/or global pooling layers.

5. Flatten Layer: Converts multidimensional data into a 1D array. This is necessary because Dense layers expect input as a one-dimensional vector rather than a multi-dimensional matrix.

6. Fully Connected Layer (Dense Layer): It is a fully integrated layer for distribution services and is widely used. Otherwise, they are called dense layers, and these layers receive higher properties. The map generated from the previous layer is converted into a probability vector indicating the probability of the input falling into each category.

7. Dropout Layer: Used to prevent overfitting by randomly setting a fraction of input units to zero during training.

A Summary of the Review Articles

Researchers have written a number of papers in recent years that concentrate on the automatic identification of respiratory illnesses including1 pneumonia and Covid-19. The dataset Chest X-ray14, made available by Wang et al. in 2017 [4], was used in the research conducted by Varshni et al. [3]. A deep learning-based method for the categorization of COVID-19 and pneumonia infection was presented by Mahmud et al. [5]. The Kaggle database provided the dataset for these investigations [2]. Li et al.'s method [1] for COVID-19 infection detection was proposed. The suggested method successfully distinguishes between Community-Acquired Pneumonia (CAP) and COVID-19 pneumonia. The COVNet deep learning model, which

Table 3: Some Authors list with their work.

Sr. No.	Authors	Objective	Dataset	Deep Learning Based Method	Result
1	Li et al.'s [1]	COVID-19 infection detection	dataset consisted of 4356 chest CT exams from 3,322 patients	COVNet deep learning model	sensitivity and specificity rate 90% and 96%
2	Kermany D [2]	Chest X-Ray Images for Classification	OCT dataset, dataset includes 84,484 images	Capsule network	accuracy of 99.6%,
3	Varshni et al. [3]	Diagnosis of chest conditions	dataset Chest X-ray14 consists of 112,120 frontal chest X-ray images	DenseNet-169 and Support Vector Machine	more than 90% accurate
4	Wang et al. [4]	Classification and Localization of Common Thorax Diseases	dataset Chest X-ray14 consists of 108,948 frontal-view X-ray images	DenseNet-169	accuracy of 80%,
5	Xu et al. [6]	COVID-19 infection identification	618 transverse-section CT samples	deep learning-based, Computed tomography	accuracy rate was 86.7%
6	Chowdhury [9]	screening viral and COVID-19 pneumonia	dataset comprises 3616 images of COVID-19-positive cases	Artificial intelligence, machine learning	accuracy, precision, sensitivity 99.7%
7	Heidari et al. [10]	images global contrast	dataset involving 8474 chest X-ray images	CNN model and Histogram equalization	accuracy of 94.5 %, 98.0% specificity
8	Khan et al. [11]	Enhance Images	dataset consisted of 3224 images from both COVID-19 infected and Healthy	Shear is a type of image distortion	Accuracy of 96.53%
9	N. Tajbakhsh. [12]	medical image analysis	database consisting of 121 CTPA datasets with a total of 326 Pes	CNN model fine-tuning	Accuracy of 95%
10	E. Irmark. [14]	COVID-19 disease detection	Contains 542 frontal chest x-ray images	deep convolutional neural network	accuracy of 99.20%
11	T. Rahman, A. Khandakar [18]	COVID-19 detection using chest X-ray images	dataset consisting of 18,479 CXR images	Image Enhancement technique	accuracy, precision, sensitivity, F1-score, and specificity were 95.11%, 94.55%, 94.56%, 94.53%, and 95.59% respectively
12	H. Hanafi, A. Pranolo [19]	Automatic COVID-19 disease detection based on X-ray images	45 COVID-19, 931 Bacteria Pneumonia, 660 Virus Pneumonia, 1203 Normal	autoencoder and a convolutional neural network	83.5% Accuracy
13	Trivedi et al. [21]	automatic detection of pneumonia using chest X-ray images	dataset of 5856 chest X-ray images	Deep learning, CNN based architectures, Mobile Net	97.34% of Accuracy

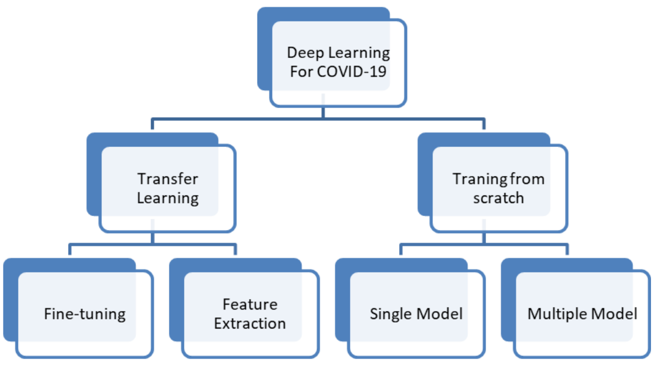

Figure 3: Tasks of deep learning to COVID-19 detection on chest X-ray images [32].

is a three-dimensional CNN architecture, is used for training. A publicly accessible dataset containing COVID-19 and Community-Acquired Pneumonia (CAP) CT scan samples is used. A sensitivity and specificity rate of 90% and 96%, respectively, were attained by the COVNet model. A deep learning-based model was proposed by Xu et al. [6] as a method for COVID-19 infection identification. Panwar et al. [7] presents a method based on convolutional neural networks, in which COVID-19 and normal images are classified using a 24-layer CNN model. In another work Hasan et al. [33] proposed weighted models of InceptionV3, MobileNetV2, VGG16 and DenseNet169 and Xception were proposed to detect pneumonia and normal cases by applying the transfer tilt concept to obtain a great performance of 92% accuracy. In **Table 3.** the various dataset and deep learning-based methods used by some Authors are listed.

Classifying images takes an extremely long time. Training a model with greater accuracy requires a larger collection of labelled data. It is costly and time-consuming to gather these datasets, though. Transfer learning strategies using already trained deep learning models could be one way to overcome these challenges. Transfer learning involves using large and diverse datasets such as ImageNet to pre-train a deep neural network model. The model must then be exported to another data set in the same area. Two possible approaches in transfer learning are feature extraction and fine-tuning.

Conclusions

This article examines Several deep learning (DL) methods for identifying COVID-19 from chest X-ray pictures are discussed in this article along with the current status of the field's research. This publication explains the various datasets and pre-trained CNN models from earlier studies. It has been determined that methods like transfer learning, data augmentation, and cross-validation can improve the generalization and adaptability of deep learning models. The article describes several datasets from earlier research. The automatic diagnosis of COVID-19 by DL techniques holds great potential; nevertheless, greater collaboration between computer scientists and medical professionals is required to develop more dependable and efficient DL models.

The deep learning methods for COVID-19 identification utilizing chest X-ray images are compiled in this review paper. Additionally, the datasets of chest X-ray images that were utilized in the methodologies that were assessed are summarized in this article. The article also discusses the tactics that have been assessed and identifies areas that could want improvement.

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