

A Systematic Review and Analysis on Deep Learning Techniques Used in Diagnosis of Various Categories of Lung Diseases

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Abstract

One of the record killers in the world is lung disease. Lung disease denotes to many disorders affecting the lungs. These diseases can be identified through Chest X-Ray, Computed Tomography CT, Ultrasound tests. This study provides a systematic review on different types of Deep Learning (DL) designs, methods, techniques used by different researchers in diagnosing COVID-19, Pneumonia, Tuberculosis, Lung tumor, etc. In the present research study, a systematic review and analysis is carried by following PRISMA research methodology. For this study, more than 900 research articles are considered from various indexing sources such as Scopus and Web of Science. After several selection steps, finally a 40 quality research articles are included for detailed analysis. From this study, it is observed that majority of the research articles focused on DL techniques with Chest X-Ray images and few articles focused on CT scan images and very few have focused on Ultrasound images to identify the lung disease.

Keywords: Lung Diseases, Deep Learning, Prediction, X-Ray, CT, Ultrasound.

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1 Introduction

Lung disease is one of the record killers in the world. Lung disease denotes to many disorders affecting the lungs. Many people around the world are suffering from lung diseases. Common cause of lung disease is smoking, some infections, genes etc. Different types of lung diseases affect different parts of lungs. Airways get affected due to asthma, chronic bronchitis, Chronic Obstructive pulmonary disease (COPD), Emphysema, cystic fibrosis, Acute bronchitis. Air sacs get affected due to Pneumonia, Tuberculosis, Emphysema, Pulmonary edema, Lung cancer, acute respiratory distress syndrome (ARDS), Pneumoconiosis. Interstitium gets affected due to Interstitial lung disease (ILD). Blood vessels get affected due to Pneumonia embolism (PE), pulmonary hypertension. Pleura gets affected due to pleural effusion, pneumothorax, Mesothelioma. Chest wall gets affected due to Obesity hypoventilation, Neuromuscular disorders.

COVID-19 is a new virus which is affecting respiratory system. Scientists believe COVID-19 has similar receptor as severe acute respiratory syndrome (SARS). The first effect of corona virus can be on lungs or on small intestine. Later, it may affect other organs like heart, kidneys, liver, and brain. Lung Ultrasound, CT scan as well as Chest X Ray are the regularly used tests to detect lung diseases. It is a highly challenging task for radiologists and doctors to identify the lung disease. Lung diseases are increasing day by day and there are similarities between different types of lung

Table 1: Top 10 countries with high death rates.

Rank	Country	Rate
1	North Korea	112.26
2	India	89.36
3	Nepal	77.08
4	Lesotho	66.40
5	Myanmar	64.49
6	Bhutan	63.66
7	Bangladesh	61.82
8	Sao Tome	60.23
9	Mali	54.82
10	Pakistan	54.47

diseases, example includes different types of Pneumonia and COVID. Considering such challenges, it becomes difficult for a radiologist or a doctor to accurately identify the disease [38, 39].

This raises a demand for computer aided diagnosis to support the health care system in identifying the disease accurately at an early stage. The Deep Learning (DL) techniques play a key role in carrying this task. The systematic review presented in this paper discusses about different types of deep learning techniques used by various researchers in diagnosing different lung diseases. The statistics of different lung diseases are included in Table 1 which shows the top 10 countries with higher death rates due to lung diseases.

According to WHO, India ranks 2 for deaths due to lung diseases. Categorizing this further, the

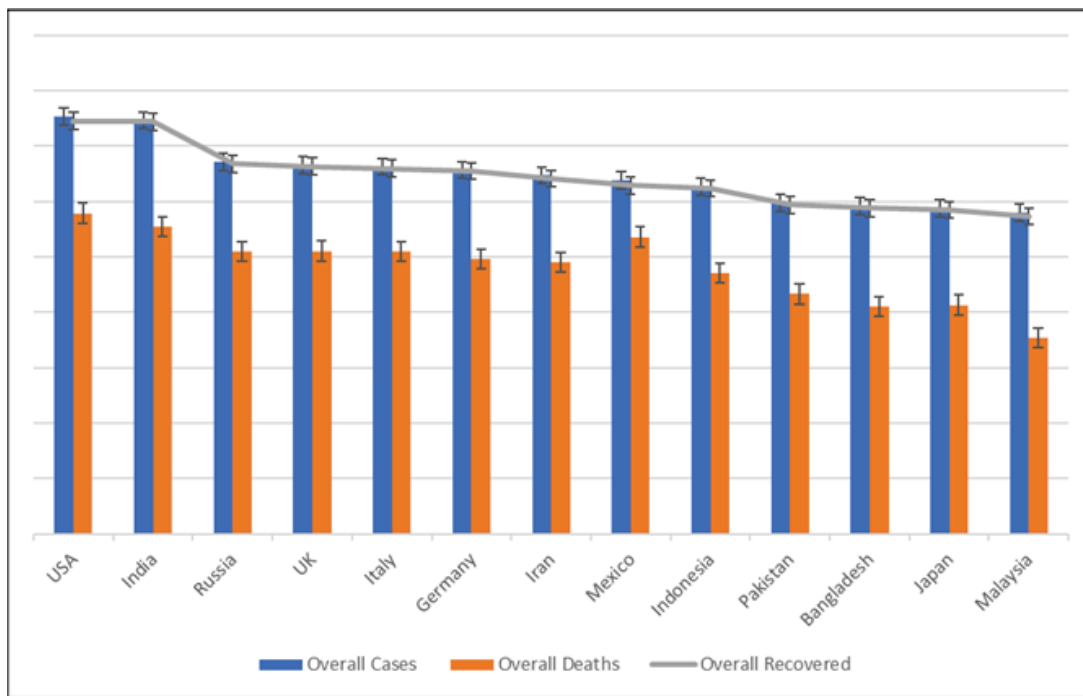


Figure 1: Total covid-19 cases, deaths, and recoveries across 16 countries.

Table 2: Statistics of COVID-19 cases in 16 countries as on 7th June 2021.

S. No	Country	Overall Cases	Overall Deaths	Overall Recovered
1	USA	34,211,228	612,378	28,122,741
2	India	28,974,152	350,631	27,282,022
3	Russia	5,135,866	124,117	4,743,202
4	UK	4,522,476	127,841	4,277,098
5	Italy	4,233,698	126,588	3,918,657
6	Germany	3,709,268	89,872	3,542,700
7	Iran	2,971,270	81,183	2,565,972
8	Mexico	2,433,681	228,804	1,939,596
9	Indonesia	1,863,031	51,803	1,711,565
10	Pakistan	933,630	21,323	864,931
11	Bangladesh	812,960	12,869	753,240
12	Japan	762,401	13,574	706,644
13	Malaysia	622,086	3,460	534,357
14	Nepal	591,494	7,990	497,960
15	UAE	585,039	1,702	564,509
16	Saudi Arabia	458,707	7,471	441,860

deaths due to Asthma is 1.85% and India ranks 18; the deaths due to Lung cancers is 1.10% and India ranks 111; the deaths due to tuberculosis is 4.78% and India rank 42. These statistics were taken from LUNG DISEASE DEATH RATE BY COUNTRY (worldlifeexpectancy.com) web site. Coronavirus cases recorded so far around the world are 174,093,954, which include 3,745,104 deaths and 57,124,854 recoveries. Table 2 shows the statistics of Corona virus in 16 countries as on 7th June 2021. (www.worldmeters.info/coronavirus). Fig. 1 depicts the same data in graph.

The diagnosis of COVID -19 through RT-PCR test takes nearly 28hrs, CT scan takes nearly 30 minutes

and CXR takes nearly 5 minutes. Though CXR gives faster results, the diagnosis may go wrong due to much similarity between CXRs of Pneumonia and COVID-19. Thus similarity function plays crucial role in learning models [2]. Considering all these, this paper focuses on different ML and DL techniques used in classifying the diseases accurately and early.

The following questions are considered in this study:

- Can DL assist radiologists/doctors in diagnosing the lung disease?
- What are different DL algorithms commonly used for lung disease detection?
- What are different types of lung images that can be used to train the DL models?

This paper consists of three sections. First section discusses on Research Methodology. Second section discuss different algorithms used in the study and as well as different datasets and number of classes considered in classifying the disease. Third section consolidates different metrics used to evaluate the algorithms. Last section provides conclusion based on this study.

2 Research Methodology

The research methodology that is carried out for performing systematic review is reported using PRISMA flow diagram. It depicts all the steps followed from identification of the articles to the selection of eligible articles for the survey. The PRISMA flow diagram is shown in Fig. 2.

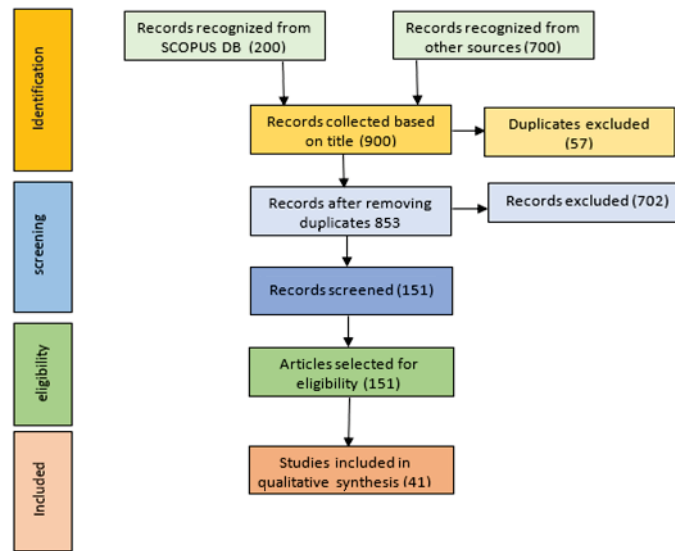


Figure 2: PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for selecting the articles (<http://www.prisma-statement.org/>).

Table 3: Number of articles chosen from 2014-2021.

Year	No. of Articles Chosen
2021	3
2020	24
2019	6
2018	2
2017	5
2015	1

Table 4: Source of articles.

Publisher	No. of Articles
ELSEVIER	17
ersJournals	1
Hindawi	2
IEEE Access	5
MDPI	1
Nature	4
NCBI	1
RSNA	4
Springer	5

Article Sources

Research articles are downloaded from different indexing sources like Scopus database and other sources as listed in the Table 4. A total of 900 articles are recognized initially. From these 900 articles, duplicate articles from different sources and those which are not relevant are excluded from consideration.

In next step, articles which have high citations were only considered. Further, articles having high citations but not certified by peer review were excluded. As accurate detection of lung disease is the focus, the articles which used CXR, CT, Ultrasound images are considered in this study. These are chosen so that the reliability of this systematic review is not compromised.

Data Collection Process

The articles from 2014 to 2021 are considered in this survey as shown in Table 4. The articles which are having high citations were considered. The articles which have high citations but not yet published are not considered. The key words used in this survey include:

- Lung disease classification using DL
- Lung disease diagnosis using DL

- Lung disease identification using DL
- Lung disease identification using DL with metrics

3 DL Techniques Used in This Study

Introduction to Deep Learning

Advances in image acquisition devices over past few years, to provide high resolution images, have improved health care system by allowing doctors to diagnose the diseases more efficiently. But as the amount of data is quite large, image analysis becomes more and more tedious and complex job for radiologists and doctors. Additionally, results can be human error prone and inconsistent. Hence, extensive research is happening in this field to automate the medical image analysis and diagnosis. AI can learn from huge set of medical images and is estimated to be 10% more accurate than an average radiologist [38, 39].

Conventional ML techniques based on supervised learning are not suitable to analyze this complex, massive and varying data. When compared to other ML

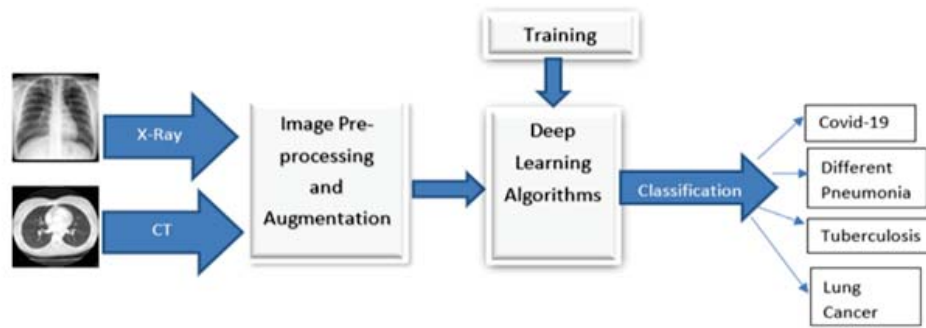


Figure 3: Block diagram of classification of lung diseases using DL.

techniques, DL is considered to have an added benefit of being able to take decisions with very less involvement from human trainers. DL is an ML technique which is based on structure of human brain. In recent times DL is getting more attention in different fields including medical imaging. DL uses layered architecture with one input, multiple hidden, and one output layers and is based on artificial neural networks. It automatically learns from massive amounts of data and as it continues to processes more and more data, it becomes more and more accurate. In medical imaging, DL can be used for various purposes like classification, image segmentation, object detection, data augmentation of limited data sets, and image transformation. Some of the DL frameworks include Microsoft cognitive toolkit, Pytorch, DLJ4, Caffe, TensorFlow, Keras.

General Flow of DL Algorithms

A general flow of DL for imaging is depicted in Fig. 3. The first task is to acquire images. Once the image is acquired using the imaging techniques, it is processed through a computer aided analysis to obtain proper medical diagnosis.

The initial step in any image processing flow is the Pre-processing to reduce/remove the noise, blur, unwanted features from the image. Frequently used pre-processing techniques are:

Filtering. Filtering aims at removing unwanted noise, blur, features to get better visualization of actual region of interest.

Segmentation. The objective of segmentation is to divide the image into regions with similar features.

Data Augmentation. Training of neural networks require massive amounts of data which is difficult to obtain due to many reasons. So, Data augmentation techniques, which apply various transformations (by adding noise, rotations, contrast, etc.), to produce different variations of datasets from available limited data.

Once the image is pre-processed, it is passed through DL algorithm to classify it into predefined labels. The DL algorithm is pre-trained and continues to learn while it is being used for classification of new images

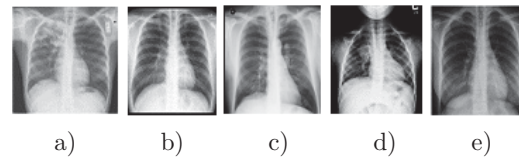


Figure 4: Sample X-ray images (a) Normal Chest X-Ray (b) Tuberculosis Lung X-Ray (c) Lung Cancer X-Ray (d) Pneumonia X-Ray images were collected from Radiopaedia.org (e) COVID-19 X-Ray image [7].

[23].

In DL, transfer learning is an important technique where the neural network is trained on a task where there is abundant data, and then the weights from this network are copied to network of actual task. This helps to obtain good accuracy even with limited data.

The advances in AI, has made it possible to apply the medical imaging models not only to latest digital images like CT or MRI but also to conventional images like X-rays and endoscopy images. The study focuses on lung disease diagnosis which predominantly uses CT / X-ray imaging. The X-ray and CT images shown in Fig. 4 and 5 are a sample of how normal and disease-affected images look like.

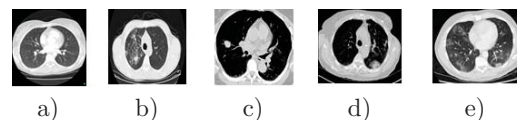


Figure 5: CT scan images of different lung diseases (a) Normal (Radiopaedia.org) (b) Tuberculosis (Radiopaedia.org) (c) Lung Cancer (Science Photo Library) (d) Eosinophilic pneumonia (Science Photo Library) (e) Coronavirus (radiogy.com).

Neural Networks

Neural networks are inspired from human neural system and use artificial intelligence for deep learning. They consist of multiple layers of interconnected neurons that are powered by activation function [6]. At high level it is composed of 3 layers: one input, multiple hidden and one output layers. Hidden layers take

Table 5: Acronyms.

DL	Deep Learning
CNN	Convolutional Neural Network
Reg-STN	Regularised Spatial Transformer Networks
SORD	Soft Ordinal regression
DBN	Deep Belief Network
DCNN	Deep Convolutional Neural Network
DECoVNet	Deep Convolutional Neural Network to detect COVID 19
DenseNet	Densely Connected Networks
DeTraC	Decompose Transfer and Compose
DFCNet	Deep Flow Collaborative Network
DLAD	Deep Learning-based automatic detection algorithm
DNN	Deep Neural Network
HSCNN	Hierarchical Semantic Convolutional Neural Network
MAN	Modified AlexNet
MC-CNN	Multi-crop Convolutional Neural Network
MODE	Multi-Objective Differential Evolution based on CNN
ResNet	Residual Networks
ODNN	Optimal Deep Neural Network
SAE	Stacked Autoencoder
LIDC-IDRI	Lung Image Database Consortium image collection

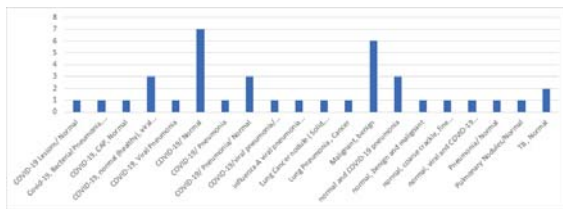


Figure 6: Graph represents different dataset classes used by authors in the study.

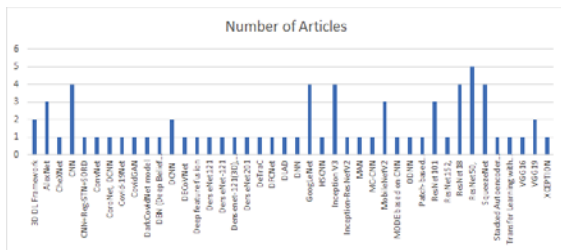


Figure 7: DL algorithms referred in different articles.

the input and produce output using activation function.

There are different types of neural networks based on their structure, depth, types of neurons used. For different types of Neural Networks, see [9]. Table 6 shows the brief review of the articles.

Datasets

Datasets used in reviewed articles are from public sources like Kaggle, Git Hub, LIDC-IDRI and few are collected from different hospitals. Table 7, which can be found in the supplement shows the details of the

dataset. The summary of different classes used by researchers is shown in Table 8 (which can be found in the supplement) and Fig. 7. Article [7] has considered 7 classes, [13] refer to 6 classes, [27, 44] refer to 5 classes, [26, 18, 11] refer to 4 classes, [28, 37, 27, 20, 21, 18] refer to 3 classes and [45, 28, 34, 24, 40, 31, 5, 17, 15, 8, 32, 25, 22, 41, 35, 16, 19, 29, 47, 43, 18, 12, 4, 46, 36] refer to 2 classes.

Data Augmentation

Data Augmentation aims at increasing the size of dataset. In DL, large number of datasets are required for training the model. As publicly available data is very less in clinical research, data augmentation is applied for images to obtain good accuracy. Data augmentation is used in different articles: [45, 15, 27, 8, 32, 22, 7, 19, 41, 35, 1, 21, 47, 33, 12, 13, 46, 11, 40, 36, 29].

DL Techniques Referred in the Articles

Table 9 and Fig. 7 shows different DL techniques used in different articles.

AUC-ROC Curve

The Receiver Operator Characteristic (ROC) curve is a metric that assesses the ability of the model to distinguish between binary classes.

		Actual Class	
		Positive	Negative
Predicted Class	Positive	True Positive (TP)	False Positive (FP)
	Negative	False Negative (FN)	True Negative (TN)

Figure 8: Confusion Matrix.

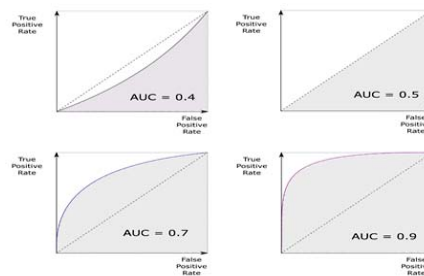


Figure 9: Represents sample Area Under Curve.

Table 6: Brief review of different articles.

Ref No	Remarks
[44]	Lung area is identified and sent to COVID-19 Net for diagnosing and predicting Covid-19 disease from different forms of pneumonia. But on deeper analysis, the features have become abstract in this model.
[45]	In this method 3D CT volumes are used. This approach follows a 2-step process. First step used UNet which was already trained, for separation of lung region. In second step this segmented image was passed to a "3D based Deep Neural Network" to predict covid-19 disease. The drawback was not using CT images of pneumonia patients which are in general difficult to segregate from those of covid-19 affected patients.
[15]	Lung region was identified from CT images. 3D and Hybrid 3D models are applied to classify Covid-19 or Pneumonia. High accuracy is achieved but model training is limited to covid -19 and pneumonia and there is a moderate decrease in sensitivity
[28]	The model 'DarkCovidNet' is based on DarNet but uses reduced number of filters and layers. The results obtained are promising for good quality X-rays but not up to mark for those with low-quality.
[34]	The model used is MODE-based CNN with 20-fold cross-validation. Main intention of using cross-validation is to avoid overfitting. When test results of proposed model are compared against those of other competitive models, it was proved that this model yields better results.
[37]	This method helps to identify chest images as - covid-19 affected or pneumonia affected or normal. This approach is composed of multiple steps, first being the elimination of noise through Fuzzy Colour technique. Second step aims at developing an image with improved quality, which is achieved by 'Stacking' (combining) the recreated images in first step with the original image. Then the stacked image is passed through couple of deep learning models - "MobileNetV2" and "SqueezeNet". Later the thousand features extracted by deep learning models are reduced to few significant features by using SMO algorithm. Finally SVM is used for classification.
[30]	The approach involved multiple phases to develop a large database. 'Feature extraction' is the initial step which is followed by 'Early Fusion', 'Resampling' and finally 'Classification'. The idea is that a large database yield better results when passed through Deep learning algorithms with appropriate depth.
[27]	This paper proposes patch-level classification using deep neural network for this purpose. Once the patch-level classes are obtained, they are combined using majority voting to obtain the final class
[31]	Spatial Transformer Networks are used to estimate the severity of disease and to identify the region of disease.
[8]	In the proposed approach DL techniques are used - 1) for classification and 2) for combining learned and hand-crafted features in order to achieve better classification accuracy. The DL method used for classification is known as 'Modified AlexNet' (MAN) and is based on SVM. Its performance is compared against 'SoftMax', 'ResNet50', 'AlexNet', 'VGG16' and 'VGG19'.
[32]	The proposed approach 'HSCNN' is a 2-level prediction model which improves the overall prediction accuracy and provides better explanation of diagnosis. At first level it classifies the nodules based on their semantic characteristics. The features from semantic feature prediction are fed to second level which predicts the final malignancy. In addition to improved accuracy the advantage of this model is that the first level can be used independently as a semantic feature generator and can be unified with other malignancy prediction models
[25]	This method is a CNN model with depth of 25 layers and 8 residual connections. First segmentation accurately identifies the lung region. Then the proposed algorithm 'DLAD' is trained with same dataset but 3 different hyper parameters. The mean of results from these 3 networks gives the final class. The advantage of DLAD is accurate detection of malignant nodules, while the disadvantage is, it is not optimized to distinguish between benign and non-benign nodules.
[20]	In this model initially ODN and LDA are applied to extract the features from CT image. Then LDR is used for classification. The model gives sensitivity, specificity and accuracy of 96.2%, 94.2% and 94.56% respectively.
[22]	In this approach 'DFCNet' is used for classification at two levels. In first level, the algorithm classifies the CT image as either cancerous or normal. At second level the cancerous image is further classified into 4 stages of lung cancer. Usage of data augmentation further improved the training process of DFCNet.
[7]	This is a special approach which uses lung sounds to classify the underlying disorders. The dataset has 7 classes of sounds which map to different lung disorders. This paper compared the performance for three ML approaches. Two of these approaches are based on classification algorithms like SVM, KNN and Gaussian mixture models (GMM) while the last one is CNN based. The results indicate that CNN approach is better.
[19]	This approach is based on Deep CNNs. It uses 'AlexNet' and 'GoogleNet' to categorize the given lung image as either ordinary or TB-affected. The images from ImageNet were used for training and testing. Multiple pre-processing techniques are applied to obtain image augmentation. Once best performing algorithms are identified, these are combined (ensemble) to achieve better predictive performance.
[41]	The proposed approach includes multiple steps. Initial step is suppression of unwanted portions of image like ribs using 'PCA' (Principal Component Analysis) for better visibility of lungs. The next step is image segmentation using 'Active Shape Model'. The next step uses 'Laplacian of Gaussian' to derive candidate nodules. Both hand-crafted and DL based methods are used to obtain features of candidate nodules. The obtained features are used to train the 'Cost Sensitive Random Forest' classifier is used for classification.
[35]	The paper evaluates 3 neural networks - CNN, DNN, SAE - in classification of input CT images as benign or malignant. The obtained results indicate that CNN is the best among the three algorithms with accuracy, sensitivity of and specificity of 84.5%, 83.96% and 84.32% respectively.
[16]	Owing to the advantage of automatic feature exploitation and performance tuning in CNN and deep belief network models over the conventional methods, this paper presents a simplified image analysis and classification pipeline for CT images based on CNN.
[26]	In this paper, five CNN based models are evaluated with three types of binary datasets and 'ResNet50' proved to achieve high accuracy. First dataset includes data for covid-19 and normal; second dataset includes data for covid-19 and viral pneumonia; third dataset includes data for covid-19 and bacterial pneumonia
[1]	DeTraC model is used to detect covid-19. DeTraC has an advantage of handling irregularities in the dataset by using a class decomposition mechanism.
[24]	ResNet18, ResNet50, SqueezeNet, and DenseNet-121 algorithms were used on 5000 chest images - 2000 for training and 3000 for testing. About 98% accuracy was achieved.
[21]	A 3D deep learning framework was developed to diagnose covid-19 disease. Accuracy is high but the article focuses on CAP and Covid -19. Other pneumonia cases were not considered.
[47]	CT images were taken as input and pre-processing is done based on Hounsfield units. Candidate region segmentation is done by using 3DCNN and Image classification model is used for finding the candidate region.
[43]	CT images were collected from different hospitals and in the first step pre-processing is done, next feature extraction and finally classification is done to find covid-19 or viral pneumonia. Training dataset considered is very small in this study.
[33]	MC.CNN model is used which learns the deep features of image to detect malignancy and diameter of affected region.
[18]	In the proposed method a chest X-ray image is passed through CNN based algorithm 'CoroNet' to identify covid-19 infection. Though the proposed algorithm is less expensive and delivered promising results when tested with limited dataset, it is expected to be tested with large dataset to confirm its performance.
[12]	Shallow networks and deep networks algorithms were evaluated in this article, and it was observed that DenseNet201 outperforms well than the remaining algorithms
[13]	Automatic module classification is done. For this ConvNets framework is designed and it is compared with SVM and K-Means algorithm. The results were observed by two radiologists who have more than 20 years of experience.
[46]	A 2D CNN model is proposed to identify the pulmonary nodules. Here 3 models are trained in order to obtain accurate model.
[4]	This paper explores usage of CNN based DL for detection and extraction of features for covid-19 disease from X-ray images.
[11]	Pre-processing, Data augmentation and Transfer learning are used in order to classify the image into predefined labels.
[40]	Proposes a model called CovidGAN which has improved performance than CNN for covid-19 detection.
[36]	This paper proposes a 2-lvel approach of feature extraction and then classification. A CNN model is built for feature extraction. The class labels are binary indicating if person is affected by pneumonia or not. The input used is X-ray images.
[29]	In this paper, author proposed a simple CNN based model. Based on the tests performed, the model gave better performance than earlier models.
[10]	This method uses high resolution CT images to predict if the patient is affected by covid-19. The model uses DL based algorithm and gives an accuracy of 95.24% per patient and an accuracy of 98.85% per image.
[14]	A model named 'Inf-Net; is proposed to detect covid-19 infected regions from CT images. In this method once features are extracted, they are aggregated to build a global map. To overcome the disadvantage of a smaller number of labelled images, a segmentation algorithm using semi-supervised learning is used, which works well even with unlabeled data.
[5]	10 Well known CNNs are used to differentiate covid-19 and non-covid-19 infections and their performance is evaluated by with well-known techniques.

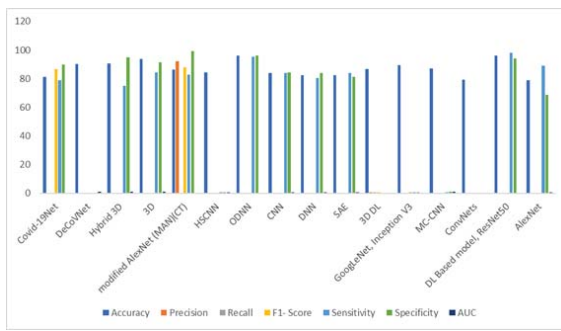


Figure 10: Accuracy, Precision, Recall, F1-Score, Sensitivity, Specificity of different DL when applied for CT images.

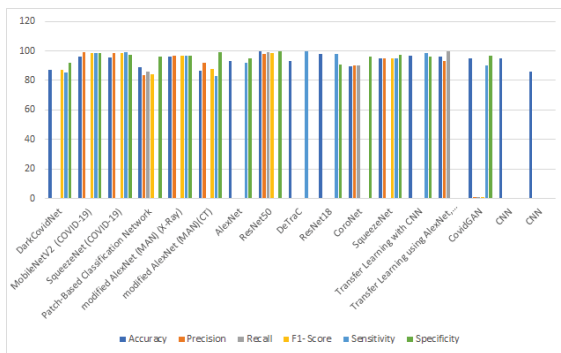


Figure 11: Accuracy, Precision, Recall, F1-Score, Sensitivity, Specificity of different DL when applied for X-Ray Images.

4 Metrics

Metrics help in assessing the performance of the model. Table 10 shows the metrics used in assessing the performance of the learning model.

Confusion matrix displays number of correctly and in-correctly predicted classes. The size of confusion matrix is based on classes. If the classes to be predicted is ‘N’, then size of confusion matrix is ‘NxN’. The confusion matrix gives simple way to compare the correctly predicted classes vs incorrectly predicted classes and thereby helps to get a fair idea of accuracy of the algorithm.

Once the values for TP, NP, FP and FN are known, we can derive metrics essential for assessment of classification model as shown in the below Table 10. The plot of ROC curve is shown in Fig. 9. This curve is created by plotting the True Positive Rate (TPR) against the False Positive Rate (FPR) at various threshold settings.

A classifier with ROC curve above the diagonal is said to be good classifier. The performance of the model improves if it becomes skewed towards the upper left corner. The Area Under the Curve (AUC) is the measure of the area under the ROC curve. Like ROC, AUC also measures the ability of a classifier to distinguish between binary classes. The higher the AUC the better the model is at predicting the binary classes. Ta-

Table 9: DL techniques used in different articles.

Ref. No	Deep Learning Algorithm	Number of Articles
[21, 47]	3D DL Framework	2
[19, 11, 5]	AlexNet	3
[12]	CheXNet	1
[35, 16, 36, 29]	CNN	4
[31]	CNN+Reg-STN+SORD	1
[13]	ConvNet	1
[18]	CoroNet, DCNN	1
[44]	Covid-19Net	1
[40]	CovidGAN	1
[28]	DarkCovidNet model	1
[16]	DBN (Deep Belief Network)	1
[19, 12]	DCNN	2
[45]	DECoVNet	1
[41]	Deep feature fusion	1
[11]	DenseNet121	1
[24]	DenseNet-121	1
[15]	Densenet-121(3D), Hybrid 3D	1
[12]	DenseNet201	1
[1]	DeTraC	1
[22]	DFCNet	1
[25]	DLAD	1
[35]	DNN	1
[19, 43, 11, 5]	GoogLeNet	4
[32]	HSCNN	1
[26, 43, 12, 11]	Inception V3	4
[26]	Inception-ResNetV2	1
[8]	MAN	1
[33]	MC-CNN	1
[37, 12, 5]	MobileNetV2	3
[34]	MODE based on CNN	1
[20]	ODNN	1
[27]	Patch-based CNN	1
[26, 12, 5]	ResNet101	3
[26]	ResNet152,	1
[24, 12, 48]	ResNet18	4
[26, 24, 21, 10]	ResNet50,	5
[37, 24, 12, 5]	SqueezeNet	4
[35]	Stacked Autoencoder (SAE)	1
[4]	Transfer Learning with CNN	1
[5]	VGG16	1
[12, 5]	VGG19	2
[5]	XCEPTION	1

Table 10: Metrics in assessing the performance.

Measure	Definition	Formula
Accuracy	Represents the number of right predictions	$\frac{TP+TN}{TP+TN+FP+FN}$
Precision	Represents positive cases rightly identified	$\frac{TP}{TP+FP}$
Recall or Sensitivity	Proportion of active positive cases that are rightly identified	$\frac{TP}{TP+FN}$
F1-Score	Geometric mean of precision and recall	$\frac{2 \cdot Precision \cdot Recall}{Precision+Recall}$
Specificity	Amount of actual negative cases that are predicted as negative	$\frac{TN}{TN+FP}$

ble 11, which can be found in the supplement, gives the metrics of DL algorithms for X-Ray and CT images.

5 Conclusion

A systematic search is performed in identifying the articles related to lung diseases. Model ResNet50 [26] for X-Ray images gives highest accuracy of 99.5%. The classes considered in the dataset are COVID-19, normal (healthy), viral pneumonia and bacterial pneumonia. Model ODNN [20] and ResNet50 [10] gives highest accuracy of 96% for CT images. The classes considered in this [20] are normal, benign and malignant and in [10] the classes are COVID-19, Pneumonia and Normal. However, in perspective of clinical research, models should be evaluated with clear criteria with the help of radiologists, prior to applying them. As day-by-day death rate is increasing because of respiratory related diseases, the ML and DL techniques can help the health care professionals in identifying the disease in early stage.

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