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Comparative Study on Lung Disease Detection and Classification Techniques using Deep Explainable

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***Abstract*- One of the main causes of death and disability worldwide is lung illness, commonly known as a respiratory disease. Pneumonia is one of the most common respiratory diseases, and according to the Johns Hopkins Bloomberg School of Public Health report titled "Lung Cancer is one of the leading cause o death among women and men, with a rate of 5 million cases per year. Pneumonia and Diarrhea Progress Report 2020," 1.23 million children under the age of five died from pneumonia in 2015. These statistics are from the Forum of International Respiratory Societies.334 million people suffered from asthma disease, different pandemics like Covid-19 affected lives of many people. Traditional methods for lung detection included blood tests, sputum tests, chest X-rays, and CT scans. More recently, deep learning models have been used to evaluate automatic analysis and classify regions of chest X-rays into diseased and non-diseased states (for example, TB and Non-TB or malignant or benign tumors)[1]. Deep learning's "black box" model is explained in detail by explainable AI, which also clarifies the patient's or examination's symptoms. In this paper we will exaggerate different deep learning and explainable techniques along with parameter comparison for diagnosis of pulmonary diseases like TB, lung cancer, pneumonia and interstitial lung diseases. This survey aims at getting acquainted with different techniques of detection of lung disease's using various types of CNN model's and various types of machine learning classifiers with explainable AI like Grad CAM, Score CAM etc for visualization of disease infected regions Also the study and analysis of different models will help researchers in their studies. Future scope and challenges are also given for further expansion of techniques.**

Keywords- Explainable AI, pneumonia, tuberculosis, deep learning

I. INTRODUCTION

Numerous common lung conditions, such as bronchiolitis, pneumonia, asthma, lung cancer, COPD, tuberculosis, etc., fall into one of three primary categories. 1.airwaydiseases 2. lung tissue conditions 3. conditions affecting the blood circulation in the lungs.

Airway Diseases-conditions making people difficulty in breathing with regards to in and out of airflow using airways.

Lung Tissue Diseases-This disease makes lungs difficulty to work in proper order by diffusing oxygen in bloodstream.

Lung Circulation Diseases-This affects way from blood to remaining part of body for delivery of tissues and organs in the body.

According to a study that estimated the incidence of cancer in 2022 using data from the "National Cancer Registry Program Report 2020" and Population-Based Cancer Registries (PBCRs), one in nine people are likely to develop cancer during their lifetime. This number was 14,61,427 (crude rate: 100.4 per 100,000).Breast and Lung cancer were most probably the cancer's found in female's and male's . Lower socioeconomic level, air pollution, exposure to tobacco or dust at work, smoking, usage of biomass fuel and firewood, indoor/outdoor air pollution, aging, occupation, gender, and lung impairment following tuberculosis all raise the risk of developing COPD. Pneumonia is an acute respiratory illness that can be brought on by bacteria or viruses. It affects a large number of people, especially in developing and underdeveloped countries where there are unhygienic living conditions, high levels of pollution, overcrowding, and a lack of medical infrastructure. Mostly pneumonia is detected by using chest x-ray examination. But it's a challenging task as its more prone to subjective variability. Infection that results in inflammation of the air sacs in one or both lungs is known as pneumonia. Pus or fluid may fill air sacs, resulting in fever, breathing difficulties, and chills. Pneumonia can be brought on by several bacteria, fungi, and viruses. Mycobacterium is the culprit behind TB. The most terrible disease, tuberculosis, can spread to not just the lungs but also other regions of the body (both latent and active TB). Research is more important for people in villages, workers in occupation.65% of people live in rural areas. It is mostly beneficial to radiologists, pulmonologists & patients.

II. RELATED WORK

A. TECHNIQUES OF DETECTING PNEUMONIA

GoogleLeNet, ResNet-18, and DenseNet-121 were employed as part of an ensemble of 3 classifiers using the ensemble weighted average technique [3].The local binary pattern, the contrast limited adaptive histogram equalization, and the contrast enhanced canny edge detection technique are three enhanced pre-processing strategies used in this research**.** Combination of MobileNet-V3, Inception-V3, a shallow CNN were used as feature extractors with pre-trained models is used[4].In order to enhance the quality of X-ray images, median filtering, histogram equalization, and intensity correction were used during pre-processing. Estimation of ROI is done using adaptive segmentation algorithm. The segmented image has been used to extract texture, invariant moment, ROI intensity, and histogram of oriented gradient (HOG) characteristics. Then, in order to improve detection accuracy, we apply the feature scaling (normalization) method. F-RRN-LSTM model is used for

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maximum accuracy and computation time[5]. SVM, KNN, ANN, and ensemble is used as soft computing method.

B. TECHNIQUES OF DETECTING TUBERCULOSIS

In this paper lung segmentation is done using U-Net network to extract region of interest and performance of 5 different CNN models was evaluated 1).Xception 2).Inception-ResNet-V2,3).ResNet-50,MobileNet,EfficientNet[6].In this paper randaugment technique was used for augmentation, augmentation was done using progressive resizing technique, A network free from normalization is used instead of normalization in batches ,also problem of gradients was solved using adaptive gradient clipping, visualization was done using Scorecam technique[7].Bayesian optimization technique was used to tune hyperparameters of CNN VGG16, EfficientNetB0, ResNet101, and DenseNet201 models[8].An ensemble of CNN models (Xception and InceptionV3)with Bayesian optimization-based weighted and soft voting are used[9]. The first method presented a hybrid method for classifying deep features using the SVM algorithm and extracting deep features using two deep learning models. For high-accuracy diagnosis, however, the second method combines the characteristics of the GLCM, DWT, and LBP algorithms with the features collected from two deep learning models. These features are then stored in feature vectors and fed into an ANN classifier[10]. GradCam was used to generate activation maps for evaluation of disease severity. A quantitative approach was used for segmentation of lung tissues based on threshold and adaptive region growing technique. An 18 layer squeeze and excitation resNet model was developed that was trained on the ImageNet dataset. The ratio of the volumetric summation of the lesion to the corresponding lung lobes was used to establish a lung "TB score".

C. TECHNIQUES OF DETECTING LUNG CANCER

Different feature extraction approaches, including the Zernike moment, Scale Invariant Feature Transform, Local Binary Pattern, and wavelet transform-based features, were utilized. This new network is known as FPSOCNN. After extraction of volumetric ,geometric, intensity features were extracted, and best feature was extracted by Fuzzy Particle Swarm Optimization Technique[12].A 2 step model GAN model for localization of nodule and segmentation of lungs was implemented by first generator U-Net network and 2nd one mask R-CNN. Discriminator used ensemble of CNNs, output of multiple CNN's was used to find final output[13]. A minimally invasive technique called liquid biopsy can be used to identify biomarkers in bodily fluids such the blood, urine, sputum, and saliva that were the subject of this investigation. This model includes a tumor detector based on cloud and stage classifier, segmentation of tumor is done using active contour model, a multiple layer CNN is used for classification of cancer stages[15].

Main motive was to improve performance through e-treatment, fast processing of real-time data, help in taking second opinion from experts.

D. TECHNIQUES OF DETECTING INTERSTITIAL LUNG DISEASE-

In this paper FVC-Net model based on Forced Vital capacity values is used to measure the prognosis of disease, to measure prognosis of disease from CT-Scan to metadata, the input for the model is image score based on degree of honeycombing from CT-scans to metadata[16].Sound recordings of patients were used by CNN to diagnose bronchial asthma[17]. objective of this study is to evaluate the feasibility of a disease-specific deep learning (DL) model based on minimum intensity projection (minIP) for automated emphysema detection in low-dose computed tomography (LDCT) scans[18].

E. LITERATURE SURVEY ON AUTOMATIC REPORT GENERATION AND MEDICAL IMAGING ANALYSIS USING EXPLAINABLE AI

This paper shows studies on classification of explainable AI techniques such as visual, textual & example based AI like class activation mapping like score CAM, Grad CAM,LIFT-CAM, Attention Based Explanation, Local Interpretable Model Agnostic Explanations, LRP and explainable AI methodologies for Automatic Report Generation like Image Captioning with Visual Explanation, Textual Explanation with concept vectors etc. Automated report generation and medical image analysis using explainable AI is shown in TABLE I.

TABLE I. AUTOMATED REPORT GENERATION AND MEDICAL IMAGE ANALYSIS USING EXPLAINABLE AI

Sr No	Name of Paper	Findings/ Conclusion	Future Scope/ Gaps	Methodology
1	[12,13]	research that is relevant to using XAI to analyze chest X-ray images and provide medical reports automatically.	1. Saliency maps can be confusing to humans 2. The explainability component isn't integrated into text generation and image processing because there aren't any quantitative methods to evaluate justifications, precision and thoroughness.	generation of medical reports 1. Captioning images with illustrations 2. Concept activation vectors in textual explanations 3. The attention mechanism was incorporated into their model, which makes predictions about subjects and generates conditional phrases related to them. Health Imaging Initial Attention-Based Mechanism 2. LIME Grad CAM and Grad CAM++

III. PROPOSED METHOD

A. STEPS FOR LUNG DISEASE DETECTION AND CLASSIFICATION

Research Methodology There are basically 5 steps in identifying diseases of lungs –

1. Image acquisition and pre-processing –First step is gathering of images like CT-scan, chest-Xray, histopathological image, smear of sputum macroscopic images etc. Different preprocessing techniques like blur image removal, edge detection, sharpening of edges,

filtering, suppression of noise and segmentation of lung images to obtain region of interest and suppression of bones,data augmentation for increasing the size of datasets is done by applying different geometrical transformation methods like scaling, rotation and shearing etc. Selection of features is done and given as input to CNN

2. Training the Artificial Neural Networks-Different neural network types, such as CNN, RNN, LTSM, and DBN, as well as deep learning application approaches, such as ensemble learning (using more than one model type for classification), transfer learning (transferring knowledge from one model to another), and GAN data balancing are trained with available dataset.

3.Classification of infected and normal images-Images are divided into healthy and diseased categories here. A probability score is provided at the conclusion to show the likelihood that an image belongs to a particular class. Models assigned probability score will be used to classify the image.

4.Explainable AI & Automatic Report generation-Disease infected regions can be shown in form of highlighted regions using Score CAM, LIME, Grad CAM, Grad CAM++ techniques. Also the report indicating overall disease information or certain specific information which is important is shown in report to experts, radiologists and doctors.[20,21]

5.Comparison with traditional methods-Comparison with existing methods and validation and testing of proposed model is done at the end.
Architecture of proposed work is shown in Fig. 1.

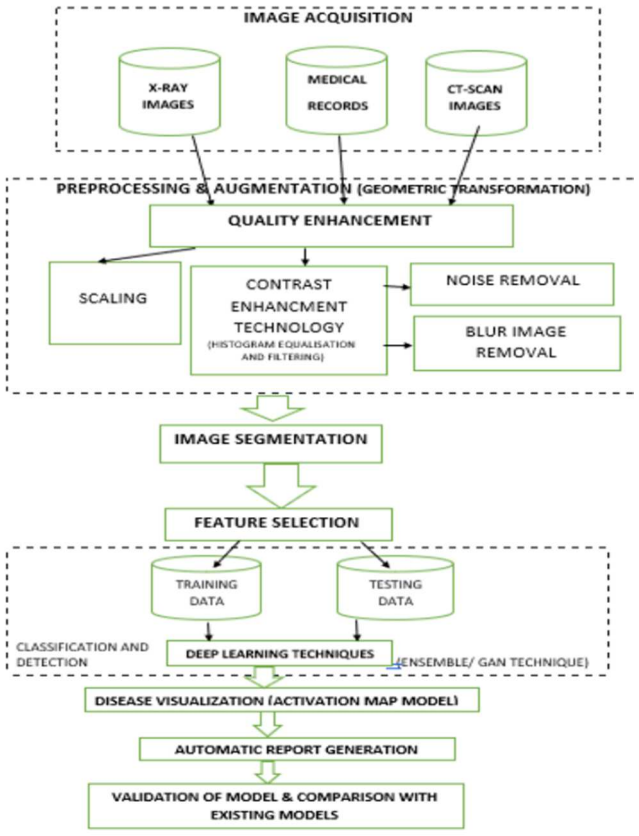

Fig. 1. Architecture of Proposed Work

IV.EXPLAINABLE AI TECHNIQUES IN HEALTHCARE [2]

XAI is model which explains and provides insight about how predictions is used to achieve causality, fairness, confidentiality, accessibility, interactivity, Privacy and confidentiality should be maintained to avoid threats from external and internal sources There are attacks like networking, false datasets, mismatching attacks, bias of system, ethical responsibilities should be crystal clear to avoid loss of patients and medical staff. Categories of Explainable AI techniques are shown in Fig. 2.

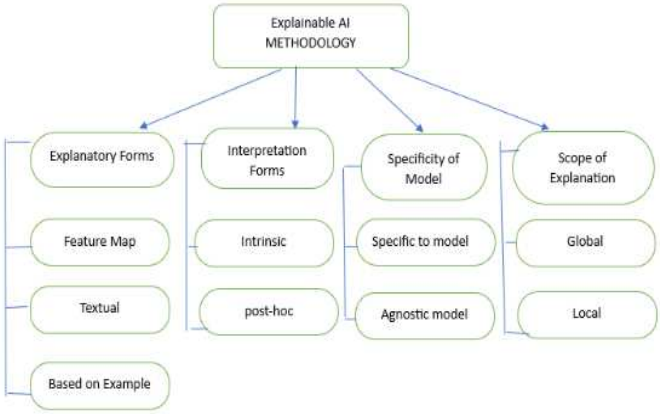

Fig. 2. Categories of Explainable AI techniques

A. Interpretation Model types-

There are basically 2 two types of ExAI techniques which a re self-explainable or interpretable models which do not depend on any external tools or methods also known as “Intrinsic model or model based Interpretability” another type is post-hoc explainable models which depends on the external model for analysis like deep neural networks with training(backpropagation, layer wise propagation, class activation mapping, etc.)

B. Specificity of Models-

There are 2 types of models under this

1. Related to deep learning or machine learning models with specific structures or details(a particular convolution known as model specific explanation.
2. Model agnostic Explanation-No particular property of model is used for e.g.-LIME (Local Interpretable model agnostic method)

C. Scope of Explanation-

1. Local-focuses on local variables which contribute to decision-making process
2. Global-Relates the output by interaction between the variables, interpretation of model globally

D. Forms of Explanation-

Feature Map-Present approximation of inputs in form of gradients showing maximum impact on the final output.

1. Textual Explanations-Decision of model in semantic description
2. Example Based-Examples similar to given model.

E. EXAI in Healthcare-

1. Saliency refers to squaring of gradients representing importance score of different input features, higher gradient more important feature

2. Class Activation Maps-
Helps to localize the most important features used for taking decisions. In this CAM uses global average pooling layer after convolution layer before fully connected layer

3. Shapley Additive Explanations-
It is based on concept of game theory where every player is given reward according to its contribution in playing game(each features contribution is measured through local explanations-Shapley values).

4.GradCAM-
Provides which part are more important for diagnosis, HiResCAM: Like Grad CAM but element-wise multiply the activations with the gradients, GradCAM++- second order gradients

5.Local Interpretable Model-Agnostic Explanations (lime)-
Helps to understand why model behaves the way it does (does local interpretation of model).
specificity when extracting features from LBP CXR pictures, outperforming MobileNet-V3 and Inception-V3. With 93.7%.

IV. COMPARATIVE TABLE OF PARAMETERS OF DEEPLEARNING MODELS

TABLE II. COMPARATIVE PARAMETERS OF DEEP LEARNING MODELS

Sr. No	Paper	Accuracy	Precision	Recall	F1-Score	Specificity	Sensitivity
1	[3]	98.81 %	98.82 %	98.80 %	98.35%		-
2	[4]	98.3 %	-	-	-	99.2%	98.9%
3	[5]	95.04 %	-	-	-	-	-
4	[6]	98.7 %	-	-	-	-	-
5	[7]	96.91				98.42%	91.81 %
6	[8]	99.29 %	99.29 %		99.29%	99.29%	99.29 %
7	[9]	97.500%	-	-	-	-	-
8	[10]	99.8 %	99.68 %		-	100%	99.54 %
9	[11]	92.15 %	0.9428	0.9308	0.937		
10	[12]	95.62 %	-	-	-	95.89%	96.68 %

According to the TABLE II below, the ensemble of GoogleNet, ResNet-18, and DenseNet-121 produces results that are more accurate, with an accuracy of 98.81%. The ensemble of GoogleNet, ResNet-18, and MobileNet v2 came in second, with an accuracy of 98.54%.[3]. From [4] Shallow CNN achieves 90.9% accuracy, 92.3% sensitivity, and 93.1%
accuracy, 95.4% sensitivity, and 95.7% specificity, the MobileNet-V3 network outperforms Shallow CNN in extracting features from CECED CXR pictures. Inception-V3 performs noticeably better than Shallow CNN and MobileNet-V3 in extracting features from CLAHE CXR pictures, achieving 95.6% accuracy, 94.9% sensitivity, and 96.2% specificity.From table [5] we get that the accuracy of F-RNN-LTSM is greater as compared to state of art methods like CDD-CNN, CDDL, COVIDetectionNet , CNN-RN, ResNeXt-50, CNN-E models.[6] from table shows EfficientNetB3 achieves highest accuracy as compared to other models. [7] shows Normalization free network model shows more accuracy and specificity, sensitivity as compared to ResNet18, ResNet50, DenseNet121, DenseNet201, InceptionV3, EfficientNet-B7.[9] Accuracy of this model was highest as compared to state of art models HCDEL , HDHFS,FRCNN, SLMHDF, SETFV, EDFPCNN, OptCNN, PreACNNF on Montgomery and Shenzhen datasets .[10] State of art methods give values as 77% to 96.20% for accuracy while proposed method accuracy was 99.8%,previous methods give sensitivity as 72% and 98.7% while proposed model gave sensitivity as 99.84%,precision 80% to 96.1% while proposed model gave 99.8%.[11] VGG16 with Neural networks outperformed well as compared to VGG16 with SVM,VGG16 with KNN,VGG16 with RandomForest,VGG16 with NB etc.[12]Proposed method gave good results as compared to Suren et al, Taruna et al, Hiram Madero et al. Hiram Madero et al, Hong Shao et al. Costa et al. methods.[13]. Comparative study of challenges and pros of models shown in TABLE IIIA

TABLE III A. COMPARATIVE STUDY OF CHALLENGES AND PROS OF MODELS

Ref No	Technique (Models used)	Pros	Challenges
[3]	Ensemble-DenseNet-121, GoogleNet, ResNet-18	Average accuracy than individual model is more in ensemble	1. Ensemble computation cost is higher 2. Some cases model fails to produce correct prediction 3. contrast enhancement other pre-processing steps to improve the image quality
[4]	Inception-V3, MobileNet-V3, and Shallow CNN	Combining the weighted features from the three image channels of LBP, CLAHE, and CECED	-
[5]	F-RNN-LSTM	1. Characteristics, including texture, invariant moment, and ROI intensity features, have been retrieved. 2.Maximize Computation time, minimize accuracy	1. Adaptive model for severity analysis for datasets with multiple classes 2.different datasets and models can be used

[6]	Xception, Inception-ResNet-V2 ,ResNeXt-50 ,MobileNet ,EfficientNet	t-SNE, GradCAM data visualization, Uses transfer learning method	1.Improving ability of generalization by equalizing normal and abnormal cases 2.Feature extraction and addition of n/w layers (pre-trained CNN)

SURVEY CONDUCTED-

This is the survey made to find information about the different pulmonary diseases such as their causes, diagnosis techniques and symptoms etc.

This survey was conducted among doctors like general practitioners ,radiologist etc. from "Bombay Hospital", "Reliance Hospital" ,few other regular practitioners

The survey results were as discussed below with a chart of data acquisition techniques during survey-

Respiratory Disease's most frequently found among patients Tuberculosis-60%, Pneumonia-40%, Interstitial Lung Disease's -20%,all of them-30%

Data Acquisition Techniques-

Different Data Acquisition Techniques shown in Fig. 3. Different modalities used are-CT Scan(70%), X-ray(80%), , Microscopy(70%),Histopathological images(50%),Sputum Smear, others Desaturation, late diagnosis , Nosocomial

Factors which causes respiratory diseases are-Allergies, smoking vitally, viral infection, occupational, infective disease's, multifunctional, pollution ,bacterial infection's

Survey of 'How many people use AI based technology' shown in Fig.4. The survey for using AI assisted software was answered as 10% people use AI based software which is actually very less so the need is to promote this software and bring it into actual use,80% said "No", rest 10% are not aware of it.

According to survey "do new technology make improvements and reduce medical treatment cost patients?" 70%(7people said "yes),10%(1 said no)and 20%(2 said none of above)neutral. Comparative study of challenges and pros of models shown in TABLE IIIB.

TABLE III B. COMPARATIVE STUDY OF CHALLENGES AND PROS OF MODELS

Ref No	Technique (Models used)	Pros	Challenges
[7]	Normalization Free Network without Batch Normalization	Rand Augment algorithm for augmentation progressive resizing (increase the strength of regularization improve system performance), Adaptive grading clipping technique(less prediction time training time Score Cam for better visualization	Boost the performance of model using GANs, collect CT-Scan images from different hospitals, make model more user friendly
[9]	InceptionV3 and Xception	1.highlight pre-processing techniques(finetuning) 2. soft voting and weighted voting for better performance	Obtain datasets from hospitals
[10]	Res-Net-50, GoogleNet	1.Dimension reduction with PCA 2.Featureclassification with SVM 3. GLCM, DWT and LBP algorithms with 2 CNN	lack of images in the tuberculosis dataset
[15]	Probabilistic Neural Networks	1. To accurately diagnose lung cancer, the lung cancer tumor segmentation and stages classification utilizing genetic algorithm (IM-LCSC) is proposed. 2. Guaranteed Convergence based Particle Swarm Optimization for accurate roi(segmentation of image)	1.Result accuracy with minimum processing time 2.Tumor classified on stages

Challenges faced by doctors in diagnosis were given as desaturation, late diagnosis, nasocomial infection, resistance to various antibiotics, diagnostic method take time for knowing definitive etiology, histopathological images always not possible, lack of infrastructural and logistic support, insensitivity of X-rays, for treatment of breathlessness symptoms in respiratory diseases doctor need to take help of inhaler's, nebulizer's, oxygen cylinder etc educating patient about this is major challenge.

Common Symptoms of respiratory diseases were chronic cough, fever, spo2 reduced, breathlessness, dyspnea, chestpain, fever, weight loss, fatigue.

What contributes to or causes respiratory conditions? (Examples include exposure to asbestos, radon, smoking, air pollution, bacteria, and viruses)

Allergies, smoking, vitally, allergic, Bacterial & viral infection, Smoking, infections, genetics, occupational, Infective disease, Multifactorial, low immunity, pollution. These were answers provided by the practioners.

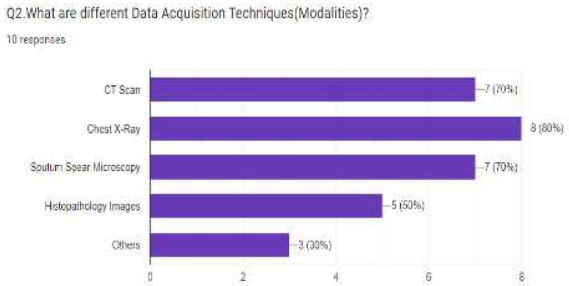

Fig. 3. Different Data Acquisition Techniques

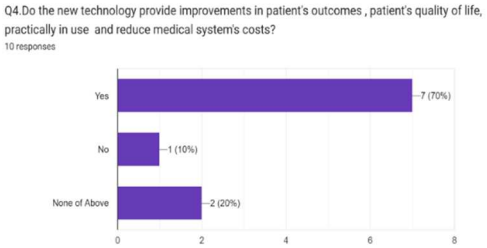

Fig. 4. How many people use AI based technology

What are the challenges faced by doctors in treatment of respiratory diseases?

infection, resistance to various antibiotics, Diagnostic methods take time for knowing definitive etiology, Breathlessness or dyspnea is one of the major symptoms in respiratory diseases, for treating this symptom, doctors need to take the help of inhalers, nebulizers, oxygen cylinder etc

,educating the patient about these processes is the main challenge for the doctors, histopathological diagnosis not always possible, lack of infrastructural and logistic support, insensitivity of X rays, No idea

What are common symptoms of respiratory diseases.?
Cough fever spo2 reduced, breathlessness. dyspnea, chest pain, fever, Chronic cough, anemia, weight loss shortness of breath, all of above, fatigue

These are the few symptoms of respiratory diseases as told by doctors.

Different datasets used for pulmonary diseases shown in TABLE IV.

TABLE IV. DIFFERENT DATASETS USED FOR PULMONARY DISEASES.

[3]	Kermany and RSNA datasets
[4]	Kaggle, RSNA and covid19 datasets
[5]	C19RD and CXIP datasets
[6]	Montgomery and Shenzhen, Belarus
[7]	TBX11k dataset on Kaggle, with 3800 healthy X-rays, 3800 sick but not TB X-rays, and 800 TB X-rays.
[9]	Montgomery County, Shenzhen
[10]	Shenzhen, TB Chest Radiography Database
[15]	LIDC-IDRI

V. CONCLUSION

We summarize our work by providing key concepts of lung disease detection using deep learning, also visualization and textualization techniques in report generation using explainable AI are highlighted. Different types of input data and tools and techniques of different lung diseases like cancer, interstitial, tuberculosis, pneumonia are also mentioned using deep learning and explainable AI. The given information can be used by researchers as part of their study and research. Also future research directions will help to improve lung disease detection systems performance.

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