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A Survey on CAD Technique for Various Abnormality Classification in Chest Radiography.

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ABSTRACT

Chest Radiography is a conventional method used for the detection and classification of various abnormalities in the thoracic region. As it is very cheap and less prone to radiation when compared to other imaging modality, it is suggested as a preliminary test for the patients with complications. Therefore, a huge number of diagnosis should be done manually. This will incur a lot of time and effort for the medical experts. Hence, Computer Aided Diagnosis is used as a tool to examine Chest X-ray. This paper focuses on the study of various algorithms using Computer Aided Diagnosis for Chest X-Ray examinations for various disorders in lungs like Cancer, Tuberculosis (TB), Pneumonia and also other disorders in the ribs and heart.
Keywords: Computer Aided Diagnosis, Chest Radiograph, Lung, Ribs, Heart

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INTRODUCTION

Computer Aided diagnosis (CAD) is an assistant for the radiologist to come up with the valid diagnosing opinion on examining any image modality. It is very difficult to interpret certain abnormalities manually for various reasons, in this scenario CAD plays a major role in evaluating various abnormalities with less duration.

Chest Radiography (CXR) is the primary imaging modality used to examine thoracic region. Even though different imaging modalities like Computed Tomography, Magnetic Resonance Imaging, Positron Emission Tomography give more details about chest when compared to chest X rays, they are costlier and prone to radiation. Hence various algorithms are developed by various researchers in this area such that CXR will meet the requirement as that of the other imaging Modalities.

In CXR five different intensities (gray level) are present such as air, Fat, Soft tissue, bone and the man made metal, which distinguish one structure from the other. The various anatomical structures present in the CXR are ribs, bones, lungs, heart, etc. Each structure can be identified by its variation in the gray level intensity. Normally the lung is filled with air and appear black abnormality in the lung can be identified by the presence of white levels. Heart and the vessels in CXR appear white because they are made up of soft tissues. Bones are normally white or shown as a variation between gray and white depend upon the category [1].The different type of abnormality can be analyzed in the CXR based on the shape of the organ, its size and its gray level variation calculate by means of the texture measure. The shape, Size and Texture are the important parameters consider mostly in all the papers in finding the abnormality in Chest X-ray.

Chest Radiography is mainly studied in two projection mode. One is Posterior- Anterior (PA) View and other one is Anterior Posterior (AP) View. Mostly for diagnosing PA is suggested. A Patient who is bed ridden is Suggested with AP. PA projection has more advantage when compared to AP projections [1]. For analyzing CXR using CAD the initial step is to find the image View. Many algorithms have been developed for analyzing the CXR view.

Computer Aided Diagnosis for chest Radiography plays a vital role as a second opinion tool for medical experts. More than 68 million CXR is taken in the United states as per the survey. The Various abnormalities that can be studied from CXR are

1. Tuberculosis, Pneumonia, Lung Cancer in the Lungs
2. Cardiomegaly, Congestive heart failure in heart
3. Rib fracture and rib orientation in ribs and Pleural effusion,Pneumoperitoneum surrounding the ribs.

The abnormalities that are mentioned above are few, apart from this number of abnormalities can be studied from the CXR.

MATERIALS AND METHODS

The paper focuses on Computer Aided diagnosis for analyzing CXR for various abnormalities using various algorithms. The paper consider in this survey are taken from the year 2002 to 2015. The survey mainly concentrates on the CAD algorithm used for Chest View findings and for finding different pathologies in the CXR like cancer in the lungs, Tuberculosis, fracture in the ribs, enlargement of heart, etc.., Mostly in all the papers two databases are used for CXR I)Japanese society of Radiological Sciences (JSRT) database which consists of 247 images with lung nodule and non-nodule images [2] 2) Segmentation in chest Radiograph (SCR) database [3] which provide results for comparative study for Segmentation of Lungs, Heart and Clavicles in CXR. Other than this database some researchers use the database developed by them using the images collected from various medical centers. The Various Methods used for analyzing CXR using Computer Aided Diagnosis are analysed under two Category

i) CAD for Determining Chest View in CXR.
ii) CAD for detection of different pathologies in CXR.

DISCUSSIONS OF CAD ALGORITHMS FOR CHEST RADIOGRAPHY:

CAD Algorithm for determining the Chest View in CXR:

The Chest Projection Information in CXR is very important to the CAD systems before starting the analysis for various abnormality Findings. It should be considered as the important preprocessing steps in evaluating CXR. The two important types of CXR projection are Posterior-anterior (PA)and Anterior-Posterior (AP) view other than this some other views are lateral view, top-down, left-right and mirroring[1]. In the PA projection the x-ray beam is passed from posterior to anterior where as in AP projection the X-ray beam is passed from Anterior to Posterior. In case of AP view Cardiothoracic ratio is greater than 50% and in the case of the PA Cardiothoracic ratio is less than 50% [4]. The PA and AP chest view are shown in Fig.1.1 and Fig.1.2 [5].

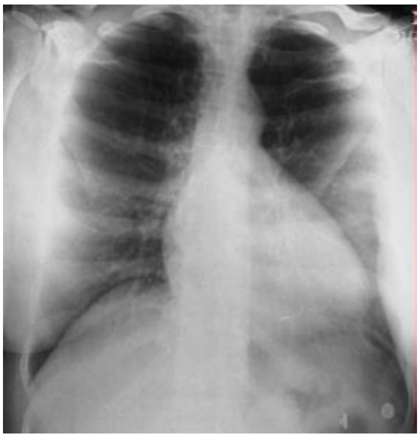


Fig 1.1: Posterior Anterior View [5] **Fig 1.2: Anterior Posterior View [5]**

In our survey [6-11] gives various algorithms developed for analyzing the CXR view and its projection using CAD. In Table.1 the algorithms used for Chest view Classification and its accuracy are discussed. In paper [7] projection view is classified by using the nearest neighbor classifier. In paper [8] both frontal and lateral view projections are analyzed by two indices such as body symmetry index and background percentage index. In paper [9] the CXR projection is determined by using various features. In paper [10] the PA and AP view is classified by using the indices of lung, scapula and clavicle as a feature set. In a paper [11] the frontal and lateral view is analyzed by using the features that are extracted from the body image profile, Cardiothoracic ratio, the pyramid of the histogram of orientation gradients and the contour based image descriptor. In this paper more than 8200 images collected by the National Library of Medicine (NLM) are considered for chest view classification . The accuracy of this work is nearly 99%.

The algorithms used for Chest View Classification in different Projection is used as a Preprocessing step before diagnosing any pathology in chest X-ray . The Projection details of CXR are very important if CXR is not in a Correct projection and the View is also not mentioned then there may possibility of false findings in X-ray images.

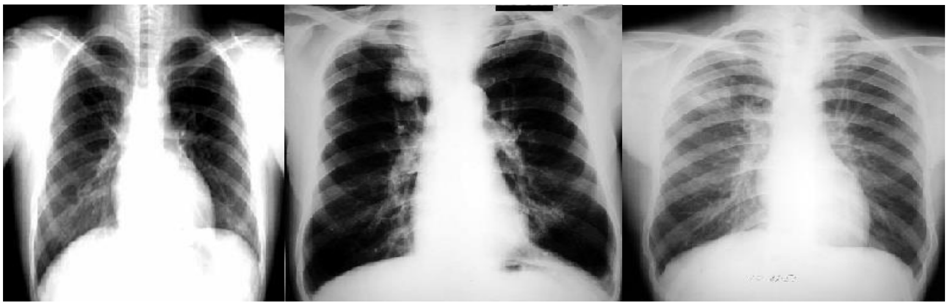
Table 1: CAD algorithms for Chest Xay View Classification

Study	Orientation	Methods Used	*Database*	No.of images	Accuracy
Arimura H [6]	To retrieve correctly the PA and Lateral CXR	Template matching technique is used.	*Database Collected from the hospitals*	48,000PA and 16,000 lateral.	99.9%
Thomas M. Lehmann [7]	Both frontal (PA/AP)and lateral view.	Nearest neighborhood classifier with distance measurements.	*IRMA(Content based image retrieval in Medical*	1867	99.7%

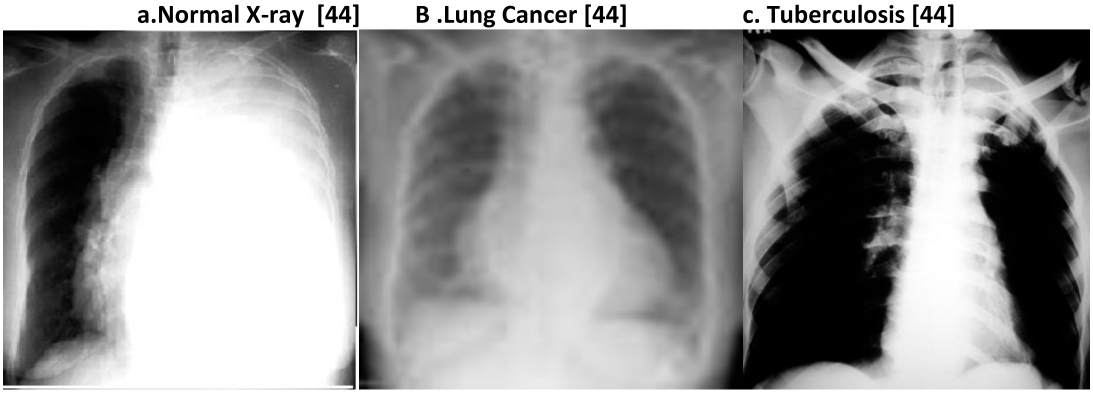
			Applications)		
Kao EF [8]	Both frontal as well as lateral view.	Linear discriminate analysis and Receiver operating characteristics analysis is used.	*Database Collected from the hospitals*	2000 frontal and 1000 lateral images.	-
Hui Luo [9]	Determine the projection of CXR	Projection is identified by the size, rotation and translation invariant features.	*Database collected from the hospitals*	-	98%
Kao EF [10]	Both posterior and anterior view	Linear Discriminant analysis is used to differentiate PA and AP view using three features	*Database collected from the hospitals*	600 PA and 600 APimages	Discriminate performance is good.
Zhiyun Xue [11]	Frontal as well as lateral view	Feature Extraction using body profile body image profile, Cardiothoracic ratio, the pyramid of the histogram of orientation gradients and the contour based image shape descriptor	*Dataset collected from the National Library of medicine.*	>8200	99%

CAD Algorithm for determining the different Pathology in CXR:

Many algorithms have been developed for diagnosing CXR using CAD for various pathology findings. The different anatomical structures present in the CXR are Lungs, heart, clavicles, ribs, trachea, mediastinum, scapula, etc. ., In fig.2 various images with different pathological conditions in chest X-ray [2]



a.Normal X-ray [44] B .Lung Cancer [44] c. Tuberculosis [44]



d. Pleural effusion [44] e.Cardiomegaly [45] f. Rib fracture[44]

Fig.2 (b,c,d.e,f). Sample images for different pathology in CXR from Chest X-ray atlas

The algorithm for finding an abnormality of these structures have been developed by many researchers. In Table.2 we discussed various algorithms, its application and the future work suggested by the researchers. Mostly in all the papers [12- 43] four steps are followed in analyzing CXR using CAD. Some steps may vary depend upon the area we are going to consider for Pathology finding in CXR. The Four steps include image Preprocessing, Region of interest (ROI) Segmentation, Feature Extraction and Classification. Image Preprocessing may include removal of noise in the CXR. If the Region we are going to concentrate is lung region, it is important to suppress the effect of ribs, bones, Clavicles as a preprocessing step as discussed in paper [19, 23, 33, 34, 38, 40]. ROI Segmentation in CXR mainly based on Rule based method, Pixel Based Method, Deformable Method and Hybrid Method [17, 18,21, 22, 25, 28, 32, 33, 41]. Feature Extraction of the Segmented region uses different feature set such as Texture based Feature [12], Geometric Features [24], Density based features [12], Region Based Features [17,42], Shape [17,23,32,34] etc., Based on the feature information the region abnormality is Classified using Various Classifier algorithms like Support Vector Machine [15, 19, 23, 26, 36], Bayesian Classifier[13], Artificial Neural Network Classifier [36]. The Various Pathological conditions in CXR Such as Tuberculosis, pneumonia, lung cancer in the lung Region, Enlargement of the heart (Cardiomegaly) , Rib fracture, etc., can be diagnosed using the different CAD algorithms discussed in the papers [12-43].

Table 2: CAD Algorithms for different Pathological findings in CXR

Study	Objective	Algorithm used	Findings in CXR	Application	Future Improvement mentioned in the paper
E-Fong Kao [12]	To detect different abnormalities in chest radiography	Density based feature and texture based feature are used.	Local abnormalities in CXR	It finds application in the clinical interpretation of CXR.	Regions Near the costrophenic angle is not considered in this work.
Rui Shen [13]	Screening of Pulmonary Tuberculosis	Automatic Segmentation with Bayesian Classifier to detect TB Cavities	Classification of CXR as image with Cavity, Non Cavity and normal	Screening of TB in Lung region with and without Cavity	The algorithm has to be improved to Provide more detailed analysis of Pulmonary TB by using geometric Features
A. Dawoud [14]	Automatic Segmentation of Lung Fields in CXR	Fusing Shape information with intensity based Thresolding	A Statistical model for Lung shape is extracted and it is used to extract the lung shape in test images.	Detection of Lung disease and TB	In this work , the algorithms are not designed to extract lung field overlapping with heart and also extraction of lung shape model also should be made automated
Uri Avni [15]	To show organ level discrimination as well as pathology level Classification in X-Ray images	Representation of image content using Bag of visual words and classification using non linear multiclass SVM	Four pathologies in CXR are detected by building a visual dictionary, constructing a histogram in multiple scales and classification using SVM with a histogram intersection Kernel.	Detection of plural effusion in right and left lung, enlarged heart and enlarged mediastinum	In this work, the algorithm is designed only for global representation it may mis detect the pathology if it is local and small
Qian Yu [16]	Early detection of Lung Cancer	Mutual information based image registration with temporal subtraction	Pathological changes in CXR are identified by comparing the current CXR with the previous one using temporal subtraction.	Pathological changes for Lung cancer in the CXR	In this work the algorithm produces good accuracy for global matching but accuracy is less in some local areas.

Study	Objective	Algorithm used	Findings in CXR	Application	Future Improvement mentioned in the paper
Sema Candemir [17]	To detect Lung Boundary	Graph cut based lung segmentation	Lung Segmentation is done by using a Static lung model and image properties like shape, boundary and region in CXR	Lung boundary extraction plays a key role in TB findings in the CXR.	In this work only static lung model is developed which is not suited for all CXR hence there is a need for dynamic lung shape model
Ryoichi Nagata, Tsuyoshi Kawaguchi [18]	To Detect and classify Lung Nodules	Lung segmentation using the adaptive shape model, nodule detection using multilevel thresoldig and nodule classification using radial gradient and template matching scheme	Lung nodule Classification as nodules or false positive in CXR using two levels of the Classifier	Lung nodule detection is very important in diagnosing lung cancer, TB, etc..,	This algorithm need optimal set of features for every training images and for each level of Specifity,
Áron Horváth [19]	To detect Lung lesions	A dynamic programming scheme to suppress bone shadow and to detect Lung lesions using gradient convergence, contrast and intensity statistics and classification using Support Vector Machine (SVM)	Lung nodule detection done by suppressing the effect of bone shadows such as rib cage and clavicle.	The presence of bone shadow is suppressed to detect the Lung nodules	Lung lesion present under the heart and the diaphragm is not considered in this work , only the lesion under the rib cage and clavicle is considered
Masataka Imura [20]	Automatic Cropping of chest X-ray images	The adaptive binarization method is used for preprocessing and template matching for cropping images	For medical diagnosing in CXR	To crop the CXR automatically for reducing the work burden of radiologist	It is not suited for all types of radiographs
Stefan Jaeger [21]	Automatic Screening of TB in PA CXR	Lung region is segmented using graph cut method and classification of lung is done by using binary Classifier	To detect abnormal CXRs with TB	Automated Diagnosis of CXR for determining TB.	Performance is slower but the results are closer to the radiologist
Min-Hsin Huang [22]		ROI(Carina) is Segmented by	Detection of position of Carina	To detect the position of the	The algorithm is not fully automatic

Study	Objective	Algorithm used	Findings in CXR	Application	Future Improvement mentioned in the paper
		integrating rule based segmentation, contrast enhancement, selective threading and morphological image processing.	in CXR	end tracheal tube of the patients in ICU(Intensive Care Unit)	
Sheng Chen [23]	To develop the Virtual dual energy (VDE) based CAD system for finding nodules that overlap with ribs and clavicles	Segmentation of the lung using multisegment active shape models and lung nodule using clustering watershed segmentation, Classification of lung nodule as normal or abnormal using nonlinear SVM.	Lung nodule detection in VDE CXR which suppresses the effect of the bones and clavicles	To detect the lung nodule that is missed by the original CAD system.	The VDE based CAD system misses some subtle nodules.
[24]	CAD system for feature extraction in lung nodule	Mathematical, textural and geometrical features are calculated from the segmented lung region	Lung Cancer detection as benign or malignant	Early detection of Lung Cancer	The CAD system will not replace the radiologist but produce nearer accuracy
Sema Candemir [25]	Lung segmentation in CXR with nonrigid Registration	Lung boundary detection with nonrigid registration by using an anatomical atlas with graph cut based segmentation	Retrieval of lung region from patient specific atlases	Detection of Tuberculosis	The algorithm is not suited for fluid filled lungs
Jaime Melendez [26]	To diagnose tuberculosis using textural lesions information	Normal or abnormality of the lung region is found by using multiple instance learning and maximum pattern margin support vector machine (miSVM)	Textural abnormalities related to TB in CXR	Detection of tuberculosis in CXR	Evaluation is done only based on the image level

Study	Objective	Algorithm used	Findings in CXR	Application	Future Improvement mentioned in the paper
Norliza Mohd. Noor [27]	Detection of three types of lung abnormalities	The pairwise discrimination method is used for lung abnormality	Detection of lobar pneumonia, pulmonary tuberculosis and lung cancer	Detection of lung related abnormality	Future work of this method concentrates on large data work
Yeqin **Sao** [28]	Lung field segmentation in PA CXR.	Joint shape and appearance sparse learning are used for lung segmentation	Accurately segment the Lung in CXR by considering the variation of lung shape and the ambiguity of lung boundary.	Detection of pulmonary disease and in hemodialysis treatment	If the appearance of the lung shape is ambiguous this algorithm will not work
Yaniv Bar [29]	Chest pathological detection using deep learning process	Convolutional neural networks (CNN) are used to classify different pathologies in CXR	To detect right pleural effusion, Cardiomegaly, and abnormal mediastinum on CXR	Detection of various chest related disease.	Chest pathology detection in CXR images is done only by using features learned from the non medical dataset
Wan Siti Halimatul Munirah Wan Ahmad [30]	To develop a Content based medical image retrieval system of CXR	Unsupervised lung segmentation is done using oriented Gaussian derivative filer combined with Fuzzy means clustering and thresolding	Lung segmentation in both PA and AP CXR	It finds application in CBMIR to isolate lung regions in both AP and PA CXR	The algorithm fails to segment lung region accurately in mobile CXR.
Vesna Zeljkovic [31]	To develop an automatic algorithm for detection of Lung Cancer	Lung cancer is found by similarity coefficient measures	To find different lung abnormalities caused by planocellular lung cancer in CXR	The algorithm finds application in detecting planocellular lung cancer in CXR images	The algorithm will not support different size and position CXR images
Haithem Boussaid [32]	To develop a system for finding anatomical shapes in CXR	To detect shape and appearance using a deformable contour model.	Lung region, heart and clavicles are segmented from the CXR	Different anatomical shapes are segmented to find various abnormalities in different region of CXR	Future work of this algorithm concentrates on 3D images.
Tuan Anh Ngo [33]	To develop the CAD technique for segmenting the lung region.	Lung Region is segmented by using a hybrid method which integrates s distance regularized level set and deep structured	Lung segmentation in CXR images.	Lung region is segmented from the overlapping structures like bones and clavicles.	This algorithm will support only JSRT database but this should be improved for supporting other databases

Study	Objective	Algorithm used	Findings in CXR	Application	Future Improvement mentioned in the paper
		Inference method			
Laurens Hogeweg [34]	To suppress the elongated structures present in the CXR.	Blind source separation and outlier detection are used for elongated structural separation	To suppress bones, ribs, clavicles and catheters in CXR images.	Lung nodule detection by suppressing the effect of elongated structures	Fully automatic system was not obtained by this method.
Fr´ed´eric Plourde [35]	To detect scoliotic rib borders in PA CXR.	Rib border is detected by using an edge following Approach with multiple-path branching and oriented filtering.	Semi-automatic detection of rib borders in PA-0° and PA-20° view in CXR.	Development of 3D reconstruction technique that will provide 3D models of the rib cage.	The algorithm requires some user interaction.
R. Sundararajan [36]	To detect the presence of Pneumoconiosis in CXR.	Multiresolution approach is used for Segmentation and SVM is used for classification	The algorithm finds the presence of Opacities in the lung region in CXR.	This method finds application in Occupational disease screening.	Only the algorithm detects the presence of Pneumoconiosis and not the stage of the disease.
Jaeil Kim [37]	To detect the presence of broken parts of ribs in CXR.	Texture and Shape features are used for detection of rib fracture.	The algorithm developed is a flexible technique for curved part o rib and quantify the presence of rib fracture in CXR.	CAD technique can be developed by using this algorithm to help medical experts	The future work of this algorithm is to present the region of interest in the rib portion where the diagnosis is missed by the clinicians
Sheng Chen [38]	To develop a CAD algorithm for separating the bony structure such as bones or clavicles.	The suppression of bone in CXR is done by using anstomically specificMultiple Massive trainining Artificial Neural Network with total variation minimization Smoothing.	The algorithm find the lung nodules that are find overlap with ribs and clavicles in CXR .	The algorithm guide the radiologist in bone-soft tissue separation for finding lung nodules	Long training time is needed for the images
Abed-Al Nasser Assi [39]	To study the traumatic rib fracture in various directions.	CXR is examined in eight different projection angle.	The result reveals that 45° AP projection performed on expiration is suggested for finding traumatic rib fracture.	It finds application in rib fracture diagnosis.	-
Mira Park [40]	To study the abnormal texture in CXR with	An image retrieval algorithm is	Lung nodule is detected from the abnormal texture	It finds application in real time	Future work involves a knowledge based method for lung

Study	Objective	Algorithm used	Findings in CXR	Application	Future Improvement mentioned in the paper
	reduction in rib shadow.	developed using a quasi Gabor filter.	analysis	systems.	nodule detection.
S. Juhász [41]	To develop the algorithm for segmentation of anatomical structures on CXR.	The active shape model is used for Segmentation.	Segmentation of lung region, ribs and clavicles in CXR.	It finds application in diagnosing chest disease.	The segmentation is done only by visual observation.
Alexandros Karargyris [42]	Development of Screening system for pulmonary Methodology	Feature extraction using region based features	Lung, and rib borders are identified with the CXRc	Screening of Tuberculosis	To find the orientation only log Gabor filter is used in this work. In future all the wavelet families are used to to improve the accuracy
Aarti Raheja [43]	To Segment heart in PA CXR.	Dynamic programming approach is used for automatic segmentation of the heart	Heart was Segmented in the CXR with accurate result.	Screening of abnormalities in heart	The algorithm may work for JSRT database but not extended to other database .

IMPROVEMENT SUGGESTED FROM THIS SURVEY:

From the Survey of various algorithms discussed in the Section.3, some suggestions are given that may be considered in developing a CAD algorithm for CXR Diagnosis.

1. In some papers CAD algorithm for finding abnormalities in CXR doesn't include the preprocessing step, Chest View Findings. So it may be included as a preprocessing step in CXR analysis.
2. Chest Projection details also not considered in abnormality Findings.
3. The CAD algorithm should be fully automatic.
4. The CAD algorithms , whatever developed before for finding abnormalities in CXR concentrate for individual anatomical structure or it may include two anatomical structures in CXR.The CAD algorithms should be developed such that it will provide an application that will find any abnormality in all the portions of the CXR.
5. Mostly all CAD algorithms for CXR concentrate on Lung abnormality findings when compared to other anatomical structures in CXR.
6. More CAD algorithms should be developed for finding abnormalities in heart, ribs, area surrounding lungs in CXR.

CONCLUSION

In this Paper Various CAD algorithm for finding Chest abnormality was discussed. The CAD algorithm for CXR find a wide application in diagnosing various disorders in the chest. It plays an important role as a second opinion tool for medical experts. CAD algorithms also reduce the work burden of medical experts by examining numerous CXR in a short period of time. But the algorithm that was developed Concentrate only on few Pathological Condition. In some papers the Preprocessing step that is chest view and projection is also not considered . Hence a CAD algorithm must be developed such that it includes Chest view and projection findings, Segmentation of anatomical structures and identification of any pathology that may present in CXR. A CAD algorithm for CXR developed by various researchers discussed in this paper will give more information for diagnosing various abnormalities in the Chest Radiography and we have discussed some improvement to be considered for developing CAD algorithms for Chest Radiography.

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