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AN ENHANCED CONVOLUTIONAL NEURAL NETWORK (CNN) MODEL FOR THE DETECTION OF LUNG CANCER USING X-RAY IMAGE

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ABSTRACT

Lung Cancer is a life-threatening disease which can be diagnosed by Medical Imaging such as X-Ray, MRI, CT Scan etc. This research presented an enhanced model using Convolutional Neural Network (CNN) to detect lung cancer using X-Ray image. Medical image processing relies heavily on the diagnosis of lung cancer images. It aids doctors in determining the correct diagnosis and management. For many patients, lung cancer ranks among the mostdeadly diseases. Many lives can be saved if cancerous growth is diagnosed early. The purported model was predominantly built on Convolutional Neural Network (CNN) architecture and the model was built with enhanced features such as Image Enhancement, Segmenting ROI (Region of Interest), Features Extraction and Nodule Classification. In preprocessing stage, the AMF (Adaptive Median Filter) filtering method was applied to eliminate noise in X-Ray image of the dataset, and quality of X-Ray image was improved with the support of CLAHE (Contrast Limited Adaptive Histogram Equalization). Secondly, K-means Clustering algorithm was used to extract the relevant feature or Region of Interest (ROI) of the lung field automatically i.e. the model was effectively trained to identify and crop the exact location of the lung field automatically. The model was able to classify the cancer nodule as either Cancerous or Non-Cancerous. The framework worked on C# platform, and used EMGU for detection of the tumour in the lung xray image. Experimental result showed that the developed system was able to detect Lung Cancer with 90.77% accuracy, 86.65% precision and 95.31% Recall/Sensitivity.

Keyword: Convolutional Neural Network, Image Enhancement, Segmentation.

INTRODUCTION

Lung Cancer is one of the most threatening diseased according to World Health Organisation (WHO) in 2018, which reports that around 1.76 million patients died from this ailment across the world. Majority of the cells in the body have specific functions and a particular life. However, cell death is part of a natural phenomenon called apoptosis *(Nasser & Samy 2019).* Cancerous cells lack the ability to die, hence, they keep growing in the body, using resources meant for other cells. Cancerous cells can form tumors, damage the immune system and cause other deviations that prevent the body from functioning right. (*Nall, 2018).*Lung cancer is a type of cancer that affects the lungs. Yu et al, (2020) stated that Lung cancer can originate from the windpipe, the main airway, or the lungs. The two spongy organs in the chest, your lungs absorbs oxygen during inhalation and expel carbon dioxide during exhalation. The primary cause of cancer-related deaths globally is lung cancer.*Islam (2023)* refers Medical Imaging is a non-invasive technique and approach used to create visual representations of the internal organs and tissues of the human body.Crucial roles have been played by Medical imaging in various areas such as healthcare, cardiology, neurology, oncology, radiology etc(*Chola et al.,2022).*Medical Image Technique is a technique that have been adopted over a period of time in the detection of lung cancer. Radiologists and Physicians tend to make use of X-Ray and CT Scan more to detect lung cancer, that is why most recommendation by Doctors for Lung cancer are X-Ray and CT Scan. (*Goyal & Singh, 2021).*

Today, X-ray, CT Scan, Low dose computed tomography (LDCT) are popular in detecting lung cancer. Designing a Convolutional Neural Network (CNN) model that can accurately detect cancer of the lung is will reduce the amount of errors that will arise from wrong diagnosis and this will possibly help save lives especially when treatments are administered early enough.

One the essential part of a patient's EHR (Electronic Health Record) is the Medical images, the results by medical images are presently interpreted by human radiologists who are often limited by their experience, fatigue and speed. (Keret al, *2018*).

Convolutional Neural Network is a method in medical imaging that enables patterns in medical images to be read and recognized, it can also be used for diagnosingmedical diseases from medical imaging. It makes use of complex Convolutional Neural Network algorithm to help process the detection, prediction and diagnosis accurately. It does so by combining the features of the image that can be used for classification and some metrics of the image. Different methods can be used; however, they have their advantages and disadvantages. A chest x-ray is mostly the first investigationfor diagnosing cancer of the lungs. The problem of misdiagnosis is usually caused by the noise, blurriness and obscurities of the X-Ray image, which can make the clinician miss vital details thereby leading to misdiagnosis and this can lead to the death of patient.

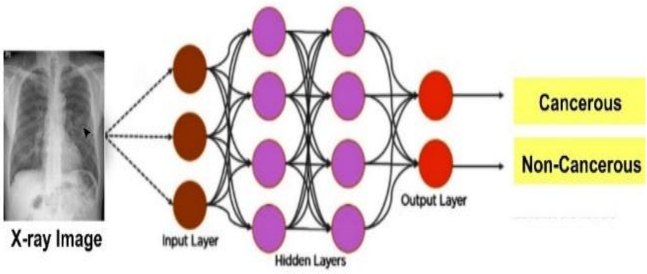

Fig 1: Convolutional Neural Network to detect Cancer from an X-ray Image

This research work focused on how to detect cancer from X-ray images, which is the most widely used and oldest imaging modality. Its principle is based on the fact that it absorbs different quantity of x-ray radiation which produces the images of the body's internal structures. (*Chapman, 2009*).

The dataset used in designing the model consist of a large amount of Lung X-ray. The purported model can help detect lung cancer accurately since the model was built with a large x-ray dataset, this will reduce the death rate caused by lung cancer because the diagnosis will be accurate.

The aim of the research was to develop a Convolutional Neural Network (CNN) Model for the detection of Lung Cancer from X-ray Images by denoising an Adaptive Median Filter Technique for the elimination of noise from the feature set, applying **Contrast Limited Adaptive Histogram Equalization to** improve the contrast of the X-Ray image, implementing K-Means Clustering Algorithm to segment and crop the Region of Interest

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(ROI) and evaluating the performance of the proposed model using parameters such as accuracy, precision and recall/sensitivity of the model.

The study will assist clinicians in detecting lung cancer at a very early stage and this will make the clinician place the patient on an early treatment that can help save the life of the patient. While different Medical Imaging are very important in detection of cancer, the use of x-ray to detect cancer is cheaper, easily accessible and cost-effective, the exposure to radiation is very minimal put side by side with CT (Computed Tomography) Scans and MRI (Magnetic Resonance Imaging).

Wang, et al. (2021) used X-BDCNN *(Blind Denoising Convolutional Neural Network)* and low-dose X-ray image enhancement algorithm to denoise the x-ray image, before using the x-ray image as input. The researchers only enhanced the image by working on the noise. They did not take the contrast of the x-ray into consideration. The research work was limited to only denoising an X-ray Image. This research work did not dwell on how the x-ray images can be properly enhanced.

Shimazaki, et al. (2022) made use of Convolutional Neural Network to develop his model. He developed a model for detecting pathologically proven lung cancer on chest radiographs using the segmentation method. However, the model was limited by few datasets gotten from one hospital and the datasets used are only pathologically proven to be malignant. The model wasn't trained to classify the nodule as benign or to detect a normal lung.

Pawar, et al.(2023) used ensemble approach using image processing techniques and machine learning techniques. He applied noise removal filter and novel CLAHE (Contrast Limited Adaptative Histogram Equalization) model to improve the quality of the input image. He applied ELS algorithm to get his Region of Interest. He classified the model by applying Hybrid-Layer Convolutional Neural Network (HL-CNN), the projected model used Convolutional Neural Network CNN architecture with Hybrid-Layer to classify the lung cancer nodule as either benign or malignant. His work was limited to just CT (Computed Tomography) Scans and cannot be applied in the case of an X-ray Image.

Chen et al, (2020) proposed using YOLOv3 architecture model for cropping the appropriate location of the lung field automatically. Additionally, the authors compared three distinct approaches to multi-classification: training a convolutional neural network-based classifier model, the one-versus-one scheme, and the one-versus-all scheme. The majority of common pulmonary diseases seen in children on chest X-rays are acute lower respiratory infections. A computer-aided diagnostic scheme was created for these cases. This study excluded the possibility of other respiratory infections broughton by upper-lower respiratory infections.

Shimpy& Rajiv (2020) applied Soft computing techniques for classifying patient's chest X-ray images for the purpose of predicting lung diseases such as pneumonia and Covid-19. The researchers failed to make use of large datasets as lung diseases are numerous.Nivea Kesav & M.G (2022).

Jibukumar, (2021), in order to address the issues such as architectural complexity and time for execution of CNN classification model of brain tumour, the researchers of this article developed uncomplicated classification prototype by applying RCNN model with two channels in CNN. Primarily this work aimed to build the low-complexity CNN architecture for classifying the tumors from MRI images, and productively the developed model has attained the accuracy of over 98%.

A model for low-dose X-ray image enhancement called the X-BDCNN is the foundation of the current system.X-BDCNN made use of two networks. One was used to estimatethe noise level of the input noise X-ray image while the other was used toobtain the residual noise image by taking the noisy X-ray image andthe estimated noise level as input, the end result is a denoised X-ray image. The authors did a good job with this, however, a denoised x-ray image is not enough to spot out lung cancer accurately from an x-ray image; hence the need for an improved model.

MATERIALS AND METHODS

Methodology is the study ofresearch techniques, the techniques themselves, or the philosophical analysis of related presumptions. The system development methodology known as Object Oriented Methodology (OOM) promotes and facilitates the reuse of software components. By using this methodology, a computer system can be created piece by piece, allowing for the efficient reuse of already existing components and the sharing of those components by other systems

Lungs Cancer Datasets

Lungs Cancer Dataset, known as National Institutes of Health Chest X-Ray Dataset (ChestX-ray8) was used to design the model. However, in this work, Chest X-ray Images, cancer images datasets were utilized.ChestX-ray8 dataset comprises of 112,120 frontal-view X-ray images of 30,805 unique patients. There are fifteen classes in total—fourteen for diseases and one for "No findings.". "Nofindings" or one or more of the following disease classes can be identified in images: Pleural thickening, Cardiomegaly, Atelectasis, Consolidation, Infiltration, Pneumothorax, Edema, Emphysema, Fibrosis, Effusion, Pneumonia, Pleural_thickening, and Hernia. The total number of zip files is 12, and their sizes vary from 2 to 4 gigabytes.

Adaptive Median Filter Image Denoising Technique

In the field of image processing, image restoration is the most important task. The presence of noise in an image can cause it to become corrupted. Typically, the median filteris employed to eliminate the existence of this type of noise; however, it is effective up to 20% of noise in the image. Therefore, adaptive median filtering is another image restoration technique that can be used to get a better image restoration. It is particularly effective for noise intensities greater than 20 percent.

Adaptive filtering preserves edges and other minute details in the image, which is an advantage over median filtering.

Algorithm For Adaptive Median Filtering Algorithm

Step 1: Identify the size and first address of the original image;

Step 2: Set the initial value of a memory buffer to 0 in order to temporarily store the processing results;

Step 3: Once the image has been binarized, scan its pixels and classify, in ascending order, the pixel values of each element that is nearby.

The pixel thatcorresponds tothecurrent point in the target image should then be assigned the obtained intermediate value.;

Step 4: Continue from step 3 until all of the original image's pixels have been handled;

Step 5: To finalize the filtering process, copy the running result from the memory buffer to the original image's data region.

Contrast-Limited Adaptative Histogram Equalization (CLAHE)

Contrast Limited Adaptive Histogram Equalization (CLAHE) was applied to x-ray images to balance them out. CLAHE is a type of adaptive histogram equalization (AHE) that addresses the over-amplification of noise in the contrast of an x-ray image. CLAHE divides the x-ray image into small regions known as tiles. The artificial boundaries are then eliminated by combining the nearby tiles using bilinear interpolation.

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This algorithm can be applied to improve the contrast of x-ray images. There are 2 important parameters to be considered and they are:

clipLimit– The threshold for contrast limiting is determined by this parameter. It starts at 40 by default.

tileGridSize – By doing this, the row and column's tile count is fixed. It is 8x8 by default. For the purpose of applying CLAHE, it is utilized when the image is divided into tiles.

Algorithm For Contrast Limited Adaptive Histogram Equalization (CLAHE)

Data Input: Image (actual_img)

Step 1: Read the image as actual_img

Step 2: Plot the histogram of actual_img

Step 3: Using OpenCV to apply the CLAHE_API function

Step 4: Save the new image from step 3 as "Denoised_img.jpg"

Result "Denoised_img.jpg" is the enhanced image

K-Means Clustering Algorithm for Image Segmentation

Image segmentation is the classification of an image into different groups. Dhanachandra et al, 2015 described it as one of the most popular techniques for accurately classifying an image's pixels in a decision-oriented application is image segmentation, which splits animage into several distinct regions so that the pixels have a high degree of contrast and similarity within each region.

For the Region of Interest to be localized, k-means algorithm was used to crop the original image. The actual X-ray image was used as the input of the model. K-Means algorithm makes use of a bounding box in form of a rectangle to locate the Region of Interest (ROI) of the image. The rectangle has 4 parameters which are coordinate X represents the centre of the rectangle, coordinate Y represents the centre of the rectangle, coordinate W represents the width of the rectangle while coordinate H represents the height of the rectangle.

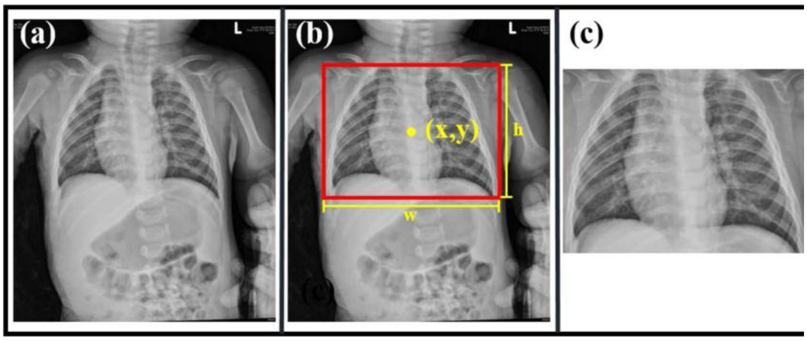

Fig 2: **(a)**Theoriginal x-ray image, **(b)**The location of the bounding box and its parameters, **(c)**The image cropped by the bounding box

Algorithm For K-MEANS Detection of Cancer

Input: Standard X-Ray image data

Output: Classify the image as Cancerous or Non-Cancerous

Step1:Use the dataset of X-ray images as input

Step2: Apply noise filtering techniques to the image to reduce noise.

Step3: Create a threshold value.

Step 4: Involves segmenting the image according to the determined threshold value.

Step 5:Involves eliminating any unwanted edges present along the border.

Step 6: Employ classification techniques to train and identify whether the provided image is cancerous or not

Step 7: Assess and examine the outcome in light of the various parameters.

Step 8: End.

RESULT AND DISCUSSION

The performance of a machine learning classifier on a dataset was examined using a confusion matrix as a metric. Metrics like recall, precision, accuracy, and specificity can be visualized using a confusion matrix. Predictive analytics tools include confusion matrices. It is essentially a table that shows and contrasts actual values with those predicted by the model. Utilizing the Confusion Matrix, the model's performance must be assessed.

True Positives (TP)-Yes, as predicted correctly, is the number of patients with lung cancer.

True Negatives (TN)-No, as predicted correctly, is the number of patients without lung cancer.

False Positives (FP)–Yes, as predicted incorrectly, is the number of patients without lung cancer.

False Negatives (FN)- No, as predicted incorrectly, is the number of patients with lung cancer.

Accuracy

Accuracy is a straightforward and crucial classification metric. It shows the percentage of real results compared to all results. When dealing with issues where the data are now skewed or improperly balanced, this evaluation technique is valid.

$$\text{Accuracy}=\frac{TP+TN}{TP+FP+FN+TN} \quad - \quad - \quad (1)$$

Precision

Measured as the ratio of expected to actual relevant outcomes, precision is ascertained. Precision metrics are sometimes referred to as positive prediction value. Consideration is given to false positives.

$$\text{Precision}=\frac{TP}{TP+FP} \quad - \quad - \quad - \quad (2)$$

Recall/Sensitivity

The ratio of outcomes that were truly relevant to outcomes that were accurately predicted is provided by recall/sensitivity. Another name for it is sensitivity. False negatives are considered.

$$\text{Recall/Sensitivity}=\frac{TP}{TP+FN} \quad - \quad - \quad -(3)$$

The model was built on CNN with the following features, which are Image Enhancement, Segmenting ROI (Region of Interest), Features Extraction and Nodule Classification. In preprocessing, primarily the AMF (Adaptive Median Filter) filtering method was applied to eliminate the noise in X-Ray image of the dataset, and quality of X-Ray image is improved by applying Histogram Equalization technique with **CLAHE (Contrast Limited Adaptive Histogram Equalization)**. Secondly, in Segmenting, ROI stage the K-Means Clustering Algorithm was used to segment the interest region (ROI) and crop the appropriate location of the lung field automatically i.e. the model was effectively trained to identify and crop the exact location of the lung field automatically, this ensured that the Lung Cancer was easily detected and for proper diagnosis. Based on the extracted features in aforementioned stage are applied to pioneering improved classification of nodule as benign or malignant was done by Convolutional Neural Network. Application of Segmentation method enabled addition of details to the detection method (bounding box) or to the classification method (determination of malignancy in an image).

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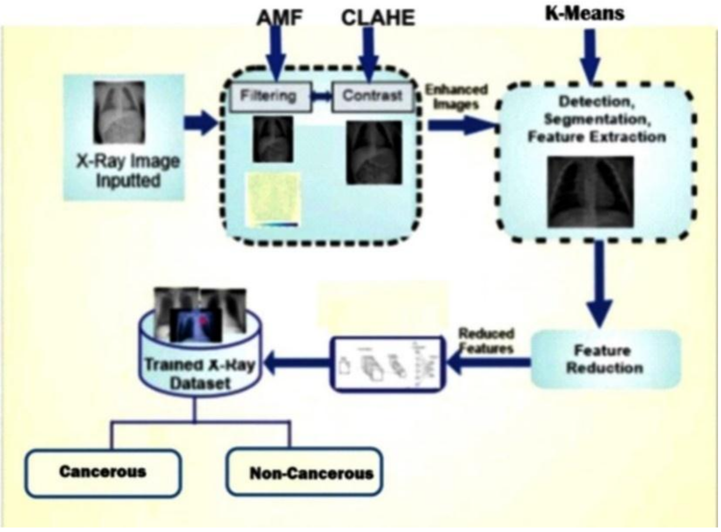

Fig 3.1: High Level Model of Developed System

		Predicted	
		Yes	No
Actual	Yes	TP 90	FN 15
	No	FP 20	TN 40

- **Actual "Yes" = 105**
- **Predicted "Yes" = 110**
- **Actual "No" = 60**
- **Predicted "No" = 55**
- **Total Predictions = 165**

TP (90): For 90 patients who have lung cancer, the model correctly predicted "Yes".

FP (20): For 20 patients who do not have lung cancer, the model correctly predicted "Yes".

FN (15): For 15 patients who have lung cancer, the model incorrectly predicted "No".

TN (40): For 40 patients who do not have lung cancer, the model correctly predicted "No".

Pseudo Code for the Developed System
BEGIN
For Every Image 1

Compute using Image Enhancement
Pre-process the image
Remove noise from the image
Apply Contrast Enhancement technique
Segment the image for Region of Interest
Extract the features from image 1 inputted

Compute using Convolutional Neural Network
Combine the results of Image Enhancement and CNN
Compare with trained datasets
Final Classification Results (Cancerous or Non-Cancerous)

System Flowchart

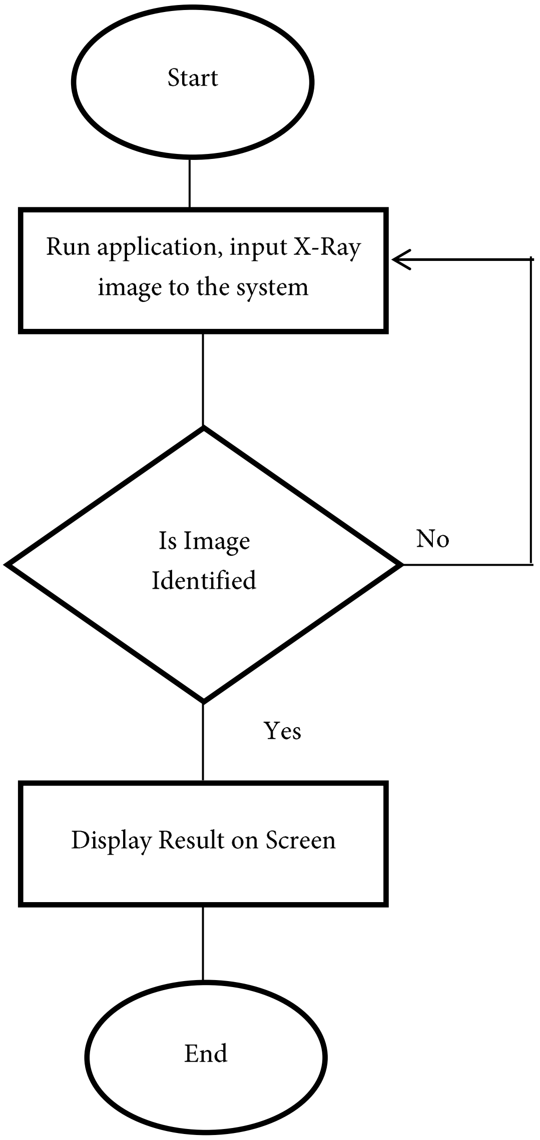

Figure 4.2: System Flowchart

Model	Accuracy	Precision	Recall/ Sensitivity
X-BDCNN (Blind Denoising ConvolutionalNeural Network)	80.1%	70%	75.7%
ConvolutionalNeural Network (CNN)	90.77%	86.65%	95.31%

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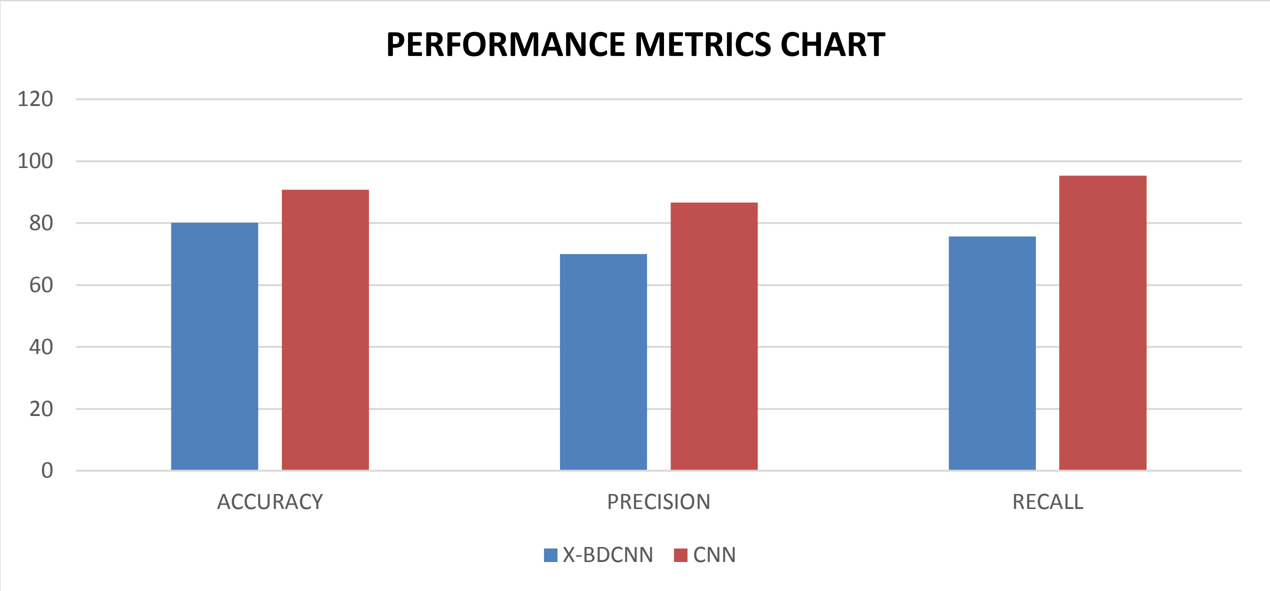
Performance Metrics of the Existing and the Proposed System



Performance Metrics Bar Chart of the Proposed System against Existing System

CONCLUSION

This study demonstrated a model that is capable of denoising an X-Ray image using Adaptive Filter, improve the contrast of an X-ray image with the aid of CLAHE**.** An enhanced development of a Convolutional Neural Network model can help the clinicians to make better diagnosis. In future, this system can be extended to detecting the stages of lung cancers and more types of lung disease detection can be added in the system.

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