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Lung Cancer Detection System Using Image Processing and Machine Learning Techniques

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ABSTRACT
In recent time the Lungs Cancer diseases are increases widely, the human body made up of with diverse fundamental organs, one of those is Lung, The Lungs are of two section right lung and left lung and function of lungs are to trade of gas which we called as breathing or respiration. The present modern lifestyle, ecological contamination is colossally expanding the Human Lungs issue. What's more, correspondingly there are various Image processing techniques are concocting the tremendous answer for the Medical field to identify and analyze the Lungs illnesses. This article is contemplating and exploring few of those Image Processing techniques, The Computer Aided Diagnosis (CAD) frameworks requires the preprocessing and highlight extraction from X-rays, Computer Tomography (CT) scan to analyze the Lungs disorders in human body, this paper is bringing the emerging image processing and machine learning techniques for implementing purpose, and by comparing the diverse classification techniques will assist to improve the accuracy in lung cancer detection system using robust segmentation and classification techniques.

Key words: Computer Aided Diagnosis (CAD), X-rays, Computer Tomography (CT), Lung Disease Diagnosis (LDD), Image Processing Technique, Lung Cancer, Classification.

1. INTRODUCTION

In the past few years the Lung Cancer became the major health diseases in human body. It is quite difficult to diagnose Lung Cancer in early stage of it, which may leads to increase the risk factor of survival of patients. Correspondingly the treatment on Lung cancer depends upon the how early this disease can be diagnose so that treatment can control on increasing (in stage) and spreading of Lung Cancer in other part of body. It is quite possible to control Lung Cancer disease by giving proper treatment, there are various treatments are available in the field of Medical Science such as Surgery, Chemotherapy and radiography as it is depend on the stage of disease, health of patient, and some other factors. The rate of survival is only 14% of patient for five years. Lung Cancer develops in respiratory epithelium of bronchial tree of lungs. It is very rare to detect the lung cancer before the age 45 years but generally Lung Cancer may be detected in the age 55 to 70 [1].

In the direction of to prevent the Lung Cancer disease and for analyzing the early stage of this disease required powerful technology to assist the doctors is mostly desirable, in particular Image Processing, Machine Learning and Artificial Intelligence technique can process the medical field data with the aid of engineering solution for the purpose of detection and diagnosing the Lung Disease. It is needed to preprocess and trained the medical field data such X-Rays, Computed Tomography (CT) scan images by applying various Neural Network, Machine Learning techniques to the input dataset [2].

There are varied Lung Disease Diagnosis (LDD) prototypes are developed by the researchers to improve the disease detection techniques in early stage of lung cancer, which will help to the practitioner or doctors. The Computed-Tomography (CT) Scan images are the mainly suitable for the invention of pulmonary nodule in Lung Cancer [3] [4].

The small pulmonary nodule can be simply detected and eventually early disorders in nodule size and number can be detected through three dimensional Computed Tomography (CT) image [5][6]. The foremost objective of this study is to summarize a variety of review articles on Lung Cancer Diagnosis and proposing the robust segmentation and classification technique.

2. RELATED WORK

The literature review on Lung Disease Diagnosis (LDD) is going to study the various article related to Lung Cancer Disease which applies image processing techniques on Computed Tomography (CT) and X-rays images.

Xiaodan Chen S. Feng, and D. Pan. (2015) [7], Author of this paper has applied the adaptive threshold algorithm, mathematical morphology and Watershed algorithm to

overcome the issues faced while diagnosing lung disease through CAD system, The researchers of this article have applied the few steps for image segmentation method; in first step they have enhanced the quality of image by applying the Gaussian filter and gradient enhancement method to reduces the noise from original Computed Tomography image(CT) then in second step the images are segmented with OTSU method thereafter in third step they have removed the main bronchus and trachea from CT lung images and then at last segmented with improved watershed transform, and testing is performed using series of Computed Tomography (CT) Lungs images to segment the area of lung parenchyma, at the result of this researcher have experimentally shown that how lung parenchyma is segmented successfully.

Manikandan T (2017) [8], Author is stated that the CAD (Comp. Assisted Diagnosis) model can be helpful to solve the lung cancer recognition in its early stage using CT images, in his paper author directed that the major four steps are there to detect the nodule in lung cancer patient, author suggested that there are certain challenges will be faced by medical professionals while diagnosing the cancer nodule is complex from normal CT images, so that these four stages will be impactful to detect the lung cancer, in first step need to remove the noise by applying various filter like mean filter, median filter, Gaussian filter, Weiner filter, Min filter, Max filter, Gabor filter, in second step there is segmentation of suspected nodule of lung cancer using different segmentation technique such as multiple thresholding, optical thresholding, global thresholding, active contour method, morphological method, watershed segmentation, shape-based method, template matching, the third step is to extracting the features (2-D features) such shape-size features, geometric features, gray scale feature, gradient features also some statistical features can be extracted from lungs to detect the nodules are cancerous or noncancerous, and final step is of classification of extracted features from lungs belongs to malignant or benign, in this steps various classifier can be applied such as support vector machine, Linear Discriminate Analysis, Generic Algorithm, Rule Based Classifier, Artificial Neural Network (ANN) were implemented successfully, as described by author in his paper still there is lot of improvement need to be done in Sensitivity, Specificity and Accuracy in existing diagnosis system.

T Aggrawal et al. (2015) [9], In their research it is proposed that, a system for the classification of cancer nodule and also a normal lung anatomy, author of this model used the most valuable thresholding values and gray scale characteristics to process the segmentation approach of the lung nodule then the geometric features are extracted from nodule and extracted geometric features are combined with LDA classification method for finding the difference between normal structure of the lung and cancer nodules. The projected system achieved 84% of accuracy, 97.14% sensitivity, 53.33% specificities, however the proposed model successfully detect the cancer nodule but still there is scope of improvement in accuracy, this model has used simple segmentation technique there is extent to have some trained learning machine to progress the classification of the cancerous nodules.

P. B. Sangamithraa and Govindaraju, S (2016) [10], in this proposed model initially CT images are pre-processed for removal of noise, in next stage the fuzzy k-means algorithm are used to segment the tumor from lungs, then further result of segmentation is improved by using K-means approach after that in next step some features of lungs are extracted from CT images such as entropy, correlation, homogeneity, SSIM and PSNR, the feature extraction used the statistics methods known as gray scale co-occurrence matrix(GLCM) and in final step categorization is performed by using supervised NN neural network like Back Propagation BPNN for identification of cancerous lungs. This model achieved the accuracy of 90.7%, still the accuracy can be improve by developing improvise classification technique such as Support Vector Machine.

Jin, X., Zhang, Y., & Jin, Q. [11], to detect Lung Cancer the proposed model used C Neural Networks (convolution NN) as classification approach in the Computer Aided Diagnostic (CAD) system. And this model has reached and achieves accuracy of 84.6%, sensitivity 82.5% and specificities 86.7%. Still the accuracy is unsatisfactory; the benefit of proposed system is that it use the circular filter in focused regions while extracting that helps to reduce the overall cost of the detection and training stage.

Zakaria Suliman Zubi and et al.[12], proposed the few methods of the data mining. The lung cancer database of patients consists of medical images Human upper body X-ray that classifies in assorted three categories; which are malignant, normal and benign. The healthy patients are non nodules which are categorized as normal patients; the lung_nodules may be initial benign stage or a normal lung without cancer, and malignant are Cancerous patients. The CAD system works in different steps, the pattern recognition is the formation of a feature extraction process and the classification process. Proposed system used X-ray chest films which obtained the less accuracy compare to CT images, study states that the future work implementation extends to use the CT images for superior diagnosis of Lung Cancer detection.

Xinyan Li S.F., Daru Pan. (2016) [13], has developed the enhanced method for segmentation approach of the lungs CT-Image, the researcher of this article have combines the kernel graphs cut algorithm and mathematical solution and also this algorithm is comparatively studied with K-means algorithm and OTSU's maximum between-cluster variance algorithm, the researchers of this article have applied the kernel graph cuts method for image segmentation from Computed Tomography (CT) Lungs images and they have proposed their method by combing the kernel graphs cut

algorithm and mathematical solution and also they have compared their proposed algorithm with K-means and OTSU algorithm at last in the experimental results they have shown in comparison is that the accuracy of two other methods is higher.

Hanan M. et al (2018) [14], In this proposed system with the support of comp. assisted diagnosis CAD) system researchers are targeting to discover the Cancer Nodules from Computed-Tomography(CT) images, this system is working in four stages: in the first stage preprocessing on Computed Tomography (CT) images is conducted which will help to improve the contrast of image and noise removal from input image dataset in Second step the system performs the segmentation of pulmonary nodules and blood vessels by applying double level of thresholding in addition to the help of morphological operation, in third step feature fusion technique is to apply for extracting the features from segmented image, the feature fusion is made up of four feature extraction methods which are valued histogram (VH) feature, histograms of oriented gradients (HOG) feature, the statistical feature of first and second order and texture Feature of the gray scale co occurrence matrix(GLCM), at last in the fourth step to get the superior accuracy there are three classifier are bring into play which are Multilayer's FF forward NN (MffNN), the second classifier is a neural network function with radial basis (RBFNN), the third classifier is used as SVM Support_Vector_Machine. The quantitative parameter used for proposed system for validating the accuracy through classifications accuracy rates (CAR), Specificity (SF), also sensitivity (S), around forty CT images were tested for the purpose of testing and final result achieved by this system is the CAR-99.06%, S-100% and SP-99.2%. But as per finding of this article there is scope of improvement in identifying benign and malignant tumor.

Silva, Carvalho, and Gattass (2004) [15], This paper presents how the lung nodule is being diagnose using Gini Coefficient and skeletonization methods, the purpose of this method is used to characterize the lung cancer nodules as class malignant or as normal class benign in CT image dataset, in this article the researcher are initially analyze the texture by applying Gini coefficient, this method help to analyze the distribution of nodules in lung with the same there is another method is used in this paper that is skeletonization which analyze the shape of the nodules, through this authors has developed their prototype and using the discriminant analysis to categories the lung nodule as malignant or benign. The evaluation of the result was based on classification and ROC curve.

Michela Antonelli B. Lazzerini, and F. Marcelloni. (2005) [16], The author of this paper has applied image processing techniques for automatic identification pulmonary parenchyma this method combine the thresholding, opening closing morphological operation, border thinning, edge recognition, edge reconstructing and also filling the region. This method used without human interference and method seems it is more flexible when it depends on the dose of the high radiations also on low radiation dose; the purpose of this method is to apply the automatic identification of shape of lung with the same it also recovers the unfilled area of lung and make the input dataset is ready for CAD system.

Ahmed, Amer, and F.E.Z. Chadi (2019) [17], In this paper authors has developed the optimizing technique to detect the pulmonary nodules using deep learning techniques in early stage, at the outset they have started to preprocessing of input image through the preprocessing image contrast is adjusted for low dose scan, then at second step the authors applied a transfer learning for the purpose feature extraction. Then in third step genetics algorithm GA is applied to the features which are extracted by using deep learning approach and also training subset of data for getting significant pulmonary nodules from optimized extracted features. And the final step is of classification of selected features is performed for recognizing the lung cancer using SVM Support_Vector_Machine and using ECLAP online lung image database the experimental result of this prototype achieved the detection accuracy 92.5%, Sensitivity is 90%, and specificity is of 95%.

Suren Makaju et al. (2018) [18], In this paper the researcher has applied the new technique for diagnosing the lung cancer in early stage of it, researcher has used the Median filter and Gaussian filter for preprocessing of Computed Tomography (CT) images rather than Gabor filter then in next stage the images are segmented using watershed algorithm, up to this stage authors can identify cancer nodules marked. In addition to authors have extracted the feature like eccentricity, perimeter and area, pixel_mean_intensity, Centroid and diameter, thereafter the classifier are used for the purpose of classification of cancer nodule using SVM, by training the prototype model is able to the classification of cancer nodule. For the Implemented purpose authors have used Lung Image Database Consortium (LIDC) [19]. The authors of this paper have increased the accuracy of detection lung cancer and classify the benign or malignant in lung cancer. This paper has reached the accuracy of lung cancer detection up to 92% from earlier detection value 86.6%, but still there this paper shows the scope of improvement in increase in accuracy and detection of various stages of lung cancers like stage-I, Stage-II, Stage-III and Stage-IV which really can help the medical field to diagnose the lung cancer and take appropriate decision in treatment to the patient.

Geraldo et al. (2014) [20], This paper aims to identify the COPD and fibrosis lung disease, for the segmentation of lung structures researchers has develop the new method is called the Adaptive Crisp Active Counter Models (ACACM), then on the basis of various attribute of lung images a spatial inter dependence matrix analyzes structural information's of the lung pictures at last the classification step classify the lung disease and health lungs as a result of this model gives 96%

accuracy to detect the normal lungs and lungs with COPD disease and hereby it is concluded by author is the proposed method is feasible assist the diagnosis of disease accordingly.

Zhuoqi and S.H. Idiopathic. (2019) [21], The main purpose of this paper is to study the CNN structure selection and comparison of effort, for detection candidate the utilization of Fast_RCNN and Faster_RCNN, to increase the network depth use residual learning neural network, for the initialization of parameter how to use the transfer learning, for optimizing the network training use of network_parameter_iterative_method all these approaches are applied to analysis, detection lung nodule, and for comparative study. In neural network the transfer learning methods produces good result but still there are few other methods can be elaborated to achieve greater result. This article created the scope for future work for the improvement of classification is how effectively can be use the cutting_edge deep_learning method.

Allison and A.M.R.W. (2017) [22], In the proposed model authors has implemented the deep learning technique to improve the accuracy of diagnosis of lung cancer using CNN network with manifold preprocessing methods [23-25]. The proposed method is different from others is due to use of use of two network with different type of inputs and for final prediction authors have used the voting system. The steps under this model by using Gaussian filter firstly performs the preprocessing on computed tomography images that CT images will go thru the randomize testing then these image will be used as training dataset for CNN network, then in second stage smoothed and unsmooth images are combined, thereafter in third stage using convolution filter the feature will go to the maximum pooling layer then the output of third stage that is features will be the input to the softmax also to the fully connected layer. In this way every CNN network will be created and at the final stage the voting system produces the output. The accuracy achieved by this model was 97.5% and the false positive rate is under 10%, the authors are expecting to increase the accuracy which needs to modify in voting system.

3. IMAGE PROCESSING ARCHITECTURE

The objectives of this annotations is to analyze and do the study of various model proposed by esteemed authors in their respective article, this paper enlighten the issues on Lung Disease Diagnosis (LDD) using Computed Tomography (CT) and X-ray images. The Image Processing Technique is the most popular because of its versatility for developing superior model and finding out the abnormality in different Computed Tomography or X-ray images [26]. The image processing technique is performing the an assortment of steps like IA acquisition of Image, IE Enhancing the image quality, IS segmentation of Images, FE extracting features, Classification and Conclusion on Computed Tomography or X-ray images. The flow of steps to be performs in Image Processing techniques are represented in figure No 1.

The steps to be perform on Computed Tomography or X-ray images:

i. Image Acquisitions
ii. Image Enhancements
iii. Image Segmentations
iv. Feature Extracting
v. Classifications of Tumor

The Computed Tomography (CT img) and x-ray image is used as input to Comp. Assisted Diagnosis (CAD) model for the preprocessing, segmentation, feature extraction, classification and analyze the final result for the judgment of lung cancer.

i. Image Acquisitions

The process of reading the input images from some defined source for the further processing, this is initial step of Image processing technique. The image size of 512 x 512 pixels has Gaussian noise in input CT image, it is possible to remove the Gaussian noise spatial filtering by smoothing the image.

ii. Image Enhancements

This Image Enhancements process is used for making image more comprehensible and undoubtedly detectable for forthcoming analysis of digital image. To get the more outstanding result in segmentation it is required to enhance the image. The essential part defines the Laplacian_operator input image to detect the image in equation (1). Output of this will get the Edge enhanced image [27].

$$\begin{matrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{matrix} \quad \text{---------- (1)}$$

At the second stage, scaled image of earlier stage image is converted to gray scale image as per in equation (2).

$$EI = I + k*LI \quad \text{---------- (2)}$$

EI: is edge enhanced image,
I : is original lung image,
LI: images acquired by convolving
I : with Laplacian operator,
k : is a constant.

iii. Image Segmentations

The image segmentations is the course of action which separates the images in to the different section that can facilitate to extract the interested information from input image. The Lung Segmentation method based on the thresholding technique initially introduced by Hu et al

(2001)[28]. Otsu's et al. (1979) [29], has indomitable the global threshold value as T, using T the image is segmented and two group of pixels is formed by this method [30].

G1=pixels_intensity_values are greater than and equal to T,

G2=pixel values are less than T.

Then the threshold values are computed for the pixel regions G1 & G2 using the average intensity value µ1 and µ2.

$$T=\tfrac{1}{2}(\mu 1+\mu 2) \quad \text{---------- (3)}$$

The process of computing value of T can be repeated until. Once the convergence is reached the threshold value will be set as T_c, then to indicate the body-pixel any intensity_pixel higher than T_c will be set as 0 and for non-body pixel the other pixel values set as to the 1. The output of this step will come out as Threshold image. Simultaneously the further stages in segmentation are background elimination.

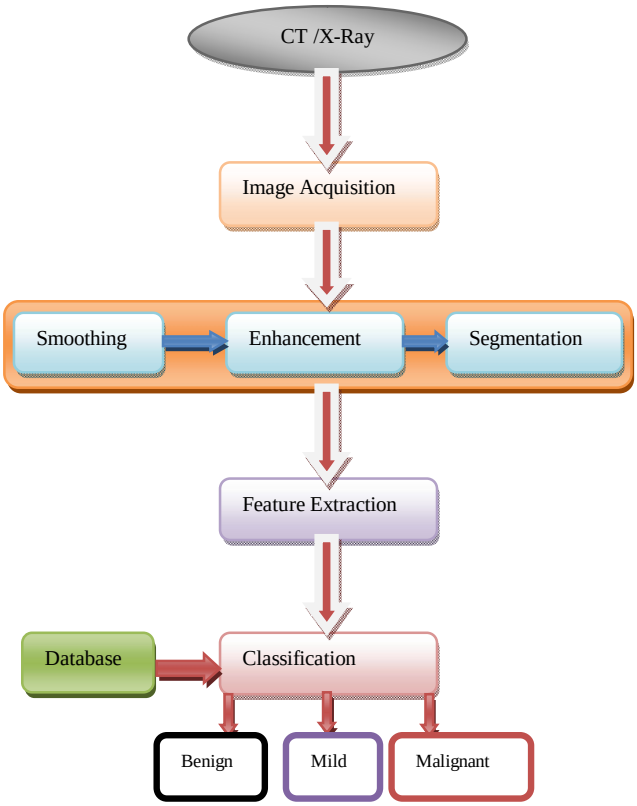

Figure 1. The steps of Image Processing Technique for Lung Disease Diagnosis (LDD) using Computed-Tomography (CT) and X-ray images

iv. Feature Extracting

Features are nothing but the some measured values or attributes that can be informative for ranking the attribute for predictive analysis. On the basis pixel based information the section of attention from segmented lungs image can be extracted. There are distinct feature extractions methods are used by researchers few of those methods are Histogram of oriented gradients features (HOGs) [31], the first and second orders statistical features [31], texture features of the gray scale co occurrence matrix [32] on the basis of wavelets coefficient, and value histograms (VH) [32].

v. Classifications of Tumor

At this stage of classification the classifiers are labeling the images in several consortiums to analyze the final result on digital image. The widely used classifiers for predictive analysis of Lung cancer detection are SVM Support_Vector_Machine [33], K-NN K-nearest neighbors [34], Decision tree and Artificial Neural Networks (ANN)[35]. This entire classification algorithm's performance is measures on the basis of parameter of sensitivity, accuracy and specificity of proposed system.

At the end the comp. assisted diagnosis model (CAD) is to compare the obtained result from classification step for Lung Disease Diagnosis (LDD) and produces the final result. The figure 1 and figure 2 are the (courtesy of LIDC-IDRI dataset)

Figure 2: Cancer Patients Lungs CT Image (LIDC-IDRI dataset) [19]

Figure 3: Cancer Patients Lungs CT Image with highlighting spot of cancer nodule (LIDC-IDRI dataset)

of low dose Lung CT images of cancer patient, normally it is challenging for medical professionals to detect the cancer nodule and come to the final decision, the red spot highlighted in figure are the cancer nodules, however it is complex to conclude the exact nodules, the proposed system performs the segmentation and classifies the cancer nodule using R-CNN robust classification techniques.

4. DISCUSSION ON METHODS AND ALGORITHMS

The research area of image processing needs to apply the various methods at the different stage of processing, to make the images unambiguous and significant to the techniques, the low dose Computer Tomography (CT) images may have in indistinguishable samples. The ambiguity in image can be resolved using preprocessing technique as discussed in previous chapter of this article.

4.1. Experimental study

The diverse techniques are used by the researchers for producing high-quality result in detection of lung cancer, correspondingly as SVM Support_Vector_Machine [34], K-NN K-nearest neighbors [34], Decision tree and Artificial Neural Networks (ANN), RBF-ANN[35]. The result of these classification techniques was adequately statistically compared and presented by Hanan et al. (2018)[14]. In table 1 it is represented that the how result is modified prior and subsequent use of Genetic Algorithm, from this it has been understand that the SVM and ANN has similar values of Accuracy and Specificity Hanan et al. (2018).

Table 1: Shows the number of features extracted prior and later using GA Algorithm, achieved Accuracy, Sensitivity and Specificity[14].

Classification Technique	Extracted Hybrid Feature Size	Size of Selected Feature	Accuracy	Sensitivity	Specificity
SVM	182	153	96.6%	100%	94.2%
RBF-ANN	182	115	95.2%	100%	97.4%
ANN	182	169	94.6%	100%	95.2%

4.2. Comparative Study of Classification Methods

There are several well known and successfully implemented methods/classifiers are discussed in this section, this study gives more prominence on functioning of the classifier which assists the researchers in conclusive step of the prototype development. The outcome of comparative study between SVM Support_Vector_Machine [36][37] and Artificial Neural Networks (ANN) [37] the both classifiers are effective in functional whereas these classifier works better at the variance in dataset size is take place. The K-NN K-nearest neighbors [38], Decision tree [37] are easy to implement and speedy classifier with good interpreter, moreover the complexity of these classifier goes increases with increase in dataset size.

Table 2: Comparative study of established classification methods:

Methods/ Classifiers	Advantages	Disadvantages
Support Vector Machine (SVM)[36] [37]	a) Highly applicable with less sample of data. b) Healthy functional for the data with high dimension.	a) It required the image intensity value. b) This is comparatively slow in meeting the expectation for larger dataset.
Artificial Neural Network (ANN)[37]	a) It imitate in periodic manner. b) It is adequately grip the larger data sample.	a) Only applicable for larger data sample. b) Difficulty to develop the prototype formation.
Decision Tree (DT)[37]	a) Easy to implement. b) The ability to integrate the multiple interpreters in an easy and step by step manner.	a) It has voracious characteristics. b) Sometimes the classifiers create more complexity which leads challenges to represent the result.
K-Nearest Neighbor (KNN)[38]	a) This is faster due to no training time. b) KNN is easy to implement.	a) It is not compatible for large dataset. b) KNN is less functional with noisy data.
Convolution Neural Network (CNN)[39]	a) Fully automatic, manual intervention is not required. Good classifier at feature detection b) High accuracy in image processing classification.	a) CNN is invariant to rotation and scale. b) Prone to overfitting due to complexity of model structure.
Naïve Bayes [40]	a) Easy to Implement and robust to irrelevant attributes. b) Tiny amount of dataset is required to run this classier	a) Assumes independence of features. b) Performance degraded when features are highly correlated.

5. CONCLUSION

The analysis on CT image segmentation is observes that the effective use of different techniques such as thresholding, classification techniques such ANN, SVM and etc. achieves

the objectives of researchers are up to the mark, but it is observed that still there is scope of improvement in accuracy, in detecting the lung cancer disease. In several studies it is inspected that the lung cancer may detected in last stage of it, which may cause of increase in risk of death of patient, as per medical term it is very much clear that the lung cancer can be treatable if it can be detected in early stage where as the several study says that sometime lung cancer doesn't give any symptoms in early stage of it, and similarly noisy CT image doesn't give appropriate result in lung disease using computer diagnosis system (CAD). There is need of such CAD system to work on robustness of preprocessing techniques, segmentation technique, noise removal methods, and accurate diagnosing classifier to achieve the objectives of Medical Imaging field by applying Image Processing technique. The proposed system overcome the challenges of preceding methods which are used in detection system and exploit the robust noise filtering methods using Autoencoder system, Segmentation and Classification techniques such as OTSU algorithm for segmentation technique and classification techniques are Decision tree and CNN. On the basis of truthful study the comparative statement on classification techniques are expressed in previous section, this paper has given brief discussion over the how Lung Disease Diagnosis (LDD) research is progressing to reach the fulfillment of medical field using Robust R-CAD system, and at the same time how challenges can be overcome in terms of future work.

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