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Lung Parenchyma Segmentation and Solitary Pulmanary Nodules in Lungs Detection Techniques-A Survey

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ABSTRACT: Lung cancer known as carcinoma of lung is major health problem all over the world both in men and women. Cancerous lung tumor can grow for many years and invade to other organ without causing any symptoms. Detection of nodules on lung wall and early detection of lung cancer is very important to improve the survival rate. Computer Aided Detection/Diagnosis systems based on imaging techniques have been developed for early detection of cancer and to classify the nodule as cancerous or noncancerous. In this paper a review of various techniques for an automated detection of lung nodules, nodule classifications are summarized.

KEYWORDS: Lung Image Database Consortium, Thresholding, Diffusion-Weighted MRI

I. INTRODUCTION

Cancer is a disease characterized by uncontrolled growth of cells anywhere in the body. According to World Health Organization it is one of leading cause for death all over the world. Lung cancer is very dangerous among all the cancers. It is uncontrolled growth of abnormal cell in one or in both lungs, grow at different rate and responds to different treatment. Main causes of lung cancer are smoking, environmental condition, heredity. Tumors in lung are begin or malignant (Cancer in one organ has spread to other part either through the blood or lymph liquid). Cancerous lung tumor can grow for many years and invade to other organ without causing any symptoms [10].

Lung cancer is of two types: Small Cell Lung Cancers (SCLC) and Non-Small Cell Lung Cancers (NSCLC) which grows and spread differently [4]. Based on severity NSCLC is assigned a stage from 0 to IV (TNM classification). Stage 0is used to describe cancer is in its original place not invaded nearby tissues. Stage I (early-stage cancer) describes there is no deep growth of small cancer or tumor into nearby tissues and have not spread to the lymph nodes or other parts of the body. Stage II and III indicate cancers or tumors are very larger in size, have grown more severely into neighboring tissue and lymph nodes, not to other parts of the body [6] [8].

Stage IV describes metastatic cancer (invaded to other organs or parts of the body).Lung cancer that has spread beyond the original tumor is difficult to cure, so early detection of cancer is very important to improve the survival rate.

Digital Image processing (DIP) techniques play an important role in many fields, among which medicine is also one (Medical imaging). DIP techniques with support of modalities like Computed Tomography (CT), Magnetic Resonance Imaging (MRI), X-ray, and Positron Emission Tomography (PET) have substantially improved the survival rate of people suffering from cancer. CT-PET plays a critical role in diagnosis and staging of cancer [4]. Most of the developed CAD systems are based on CT images because of their high quality, enhanced clarity and a reduced amount of distortion. Multidetector CT (MDCT) scan images provide information about size, contour and locality of lung tumor and/or lung tumor malignancy [1] [4] [7]. X-rays are used in CT scan to produce cross section images of body

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with scanner that rotates around the body. Computer combines these images to generate 3-D image that shows more detail information of the tumor stage and helps radiologist to determine lung lesions are cancerous or not [1]. Lungs images with nodules smaller than 1 or 2 mm can also be captured by CT. Positron Emission Tomography (PET), usually used with ^{18}F-fluoro-2-Deoxy-Glucose (FDG), has become an important imaging modality for diagnosis and staging of lung cancer [2] [3].

MRI is not suitable for moving parts of the body. Since Lungs move (inhale and exhale) for each breath and MRI scan is very rarely used to determine the lung cancer even though it provides information about size, position, shape and metastases condition of lung tumor. This scan helps to detect lung cancer that spread to brain [1] [7]. Diffusion-Weighted MRI (DWI) is another rapidly growing functional imaging modality that can be used to evaluate cancerous and noncancerous lesions throughout the body. DWI is non-invasive and does not require any radiation exposure, contrast medium, very quick technique and it provides qualitative and quantitative information that can be helpful for tumor assessment. This technique measures water movement in the tissue of the lungs and capable to detect changes in structure of cancerous tissues both in advanced and the early stages of the disease [3] [5].

To support the CAD research for lung cancer detection and diagnosis, National Cancer Institute (NCI) together with five academic institutions from United States, in 2004 launched Lung Image Database Consortium (LIDC) and Image Database Resource Initiative (IDRI) [9].

This consortium maintains well-characterized repository of spiral CT lung images with nodule effective diameter 3-30mm, truth data of images. LIDC/IDRI is web accessible international resource center for CAD system development, training and evaluation in detection of lung nodules in robust and reliable fashion. In separate relational database, LIDC also provides follow-up CT scan images information such as nodule growth, pathology reports, radiologist drawn nodule outline with scan parameters in the Digital Imaging and Communication in Medicine (DICOM) format to help CAD system developers [9].

CAD system for lung cancer work in four steps:

Image pre-processing: Pre-processing techniques like image Denoising, contrast enhancement Image enhancement are applied on input image to improve the quality of image.

Lung segmentation: It is crucial and important step to segment both lung regions in order to reduce nodule detection search time.

Nodule detection: Detection of lesions in segmented regions of both lungs.

Classification: Nodule Classification as cancerous and noncancerous based on various combination of shape and gray level distribution characteristics.

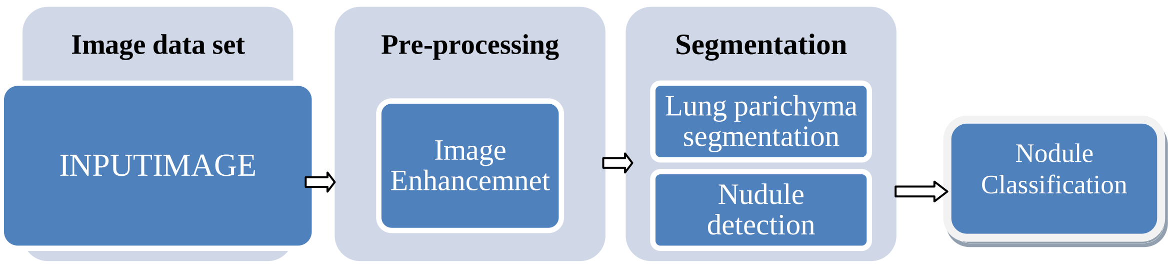

Figure 1: Lung cancer detection steps

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II. PREVIOUS WORK

Younbum Lee [11], used Generic Algorithm for Template Matching (GALM) and Lung Wall Template Matching (LWTM) in proposed CAD system for detection of lung nodules in helical CT images. Nodules in lung regions were detected using GALM.LWTM were used for detection of nodule at the lung walls. Result analysis showed that system accuracy was low since high False Positives (FP).To reduces FP13 features had been calculated. GALM used 9 features for inside lung region nodule detection. LWTM used 4 for lung wall template matching.

Yoshinori Itai et al [12] presented CAD system based on Active Contour Model (SNAKES) to segment lung regions and to locate the border of the object with no human interaction for construction of initial contour. Proposed CAD system used thorax CT image of size 512*512 bit size, acquired by Multi Detector CT scanner (MDTC).Threshold value 600 to 1000 HU was used to segment the lung area. Voxel density was used to classify nodule as cancerous or noncancerous. System performance was low since it took one minute to run on each CT slice image and extracted lung regions are different in some slices.

Zhaoxue Chen et al [13] used image thresholding technique, fast flood filling technique, erosion operation and an area-filtering operation in proposed CAD system to segment lung region based on. This method considered spatial distributing characteristic of pixel intensity for Region of Interest (ROI) that is lung region segmentation. The introduced scheme was evaluated on 75 sequence CT slice images acquired by MDTC. The result analysis showed this system was easy, efficient to segment ROI.

Pei xiaomin Guo Hongyu Dai Jianping et al [14] have applied combination of region growing and threshold method for rough segmentation of lung region. To correct the extracted boundary, boundary correction algorithm based on convex hull operation and ray casting was used. The proposed method minimized over segmentation of adjacent regions such as abdomen and mediastinum. Juxtapleural nodules and pulmonary vessels segmentation was also performed. Twenty CT datasets were used for analysis and experiments. All these datasets were acquired without an intravenous contrast agent, by using a four-detector row CT scanner. This method was compared with rolling ball method with nodule radius 3 and 5mm. Result analysis showed that proposed method was more accurate than rolling ball method.

Yang Liu et al [15] have used thresholding and region growing algorithms to segment pulmonary lung parenchyma lung regions. Proposed method consists of three steps. Thresholding was used to obtain the binary image of original input image. ROIS (nodules) were extracted by applying region growing method and circle shape descriptor was used to remove the ROI regions which were not circle shape. Semi-supervised learning method ADE-Co-Forest method was used in last step to predict remaining nodules were ROI or not. This method was evaluated on series of DlCOM files. The experimental results demonstrated that sensitivity and low false-positive were high for this CAD system compared to other systems.

A Roozgard [16] et al presented the kernel RX-algorithm for malignant nodule detection in CT images. In this proposed system pre-processing median filter and Watershed segmentation algorithm were used to reduce the noise and lung region segmentation. Resultant Bit map of the segmented tissue was then processed by morphological dilation and erosion filters. Classification of healthy non healthy nodule was done by Kernel RX-Algorithm only on segmented lung tissue of CT images. LIDC-IDRI dataset images were used for experimental purpose.

Sheng Chen et al [17] developed VDE-CADe system incorporated with Virtual Dual Energy (VDE) to detect the nodules that overlap with ribs and/or claviclesin VDE Chest Radiographs (CXRs).In VDECXRs, ribs and clavicles are suppressed by a Massive-Training Artificial Neural networks (MTANN) technique. Morphologic filtering technique was used in this proposed method to detect nodule candidates on VDE images. Nonlinear support vector classifier was applied to classify the nodule candidates based on sixty morphologic and gray-level-based features extracted from each candidate from both original and VDE CXRs. A publicly available database containing 140 nodules in 140 CXRs and 93 normal CXRs was used for testing CADe scheme. VDE-CADe scheme was compared with CADe without VDE technique. Result analysis showed that VDE-CADe achieved sensitivity of 85% with 5 FPs/image and sensitivity with FPs original CADe scheme was (78% with 5 FPs/image).

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Kiran THAPALIYA et al [18] presented new method for a segmentation of lung parenchyma of lung CT images. In this proposed method Binarisation was done at three different level used At first level Bit-plane slicing was used on original image and considered only most significant image for further processing. Connected component labeling was done on resultant binary image to label each objects and area was calculated. Next level binarisation was done on labeled objects. Boundary tracing algorithm was used in third level binarization. The proposed algorithm was tested on many different types of CT images. In this paper Jaccard and Dice Quantitative analysis methods were used to show the quantitative analysis of proposed method and compared with CHEN and region growing method. Edge information obtained was as original image compared to CHEN method.

Awais Mansoor, Member, IEEE, et al [19] proposed a novel automated-generic lung segmentation method to detect pathology in pathological lung CT image. Fuzzy Connectedness (FC) image segmentation algorithm was used in stage one to segment lung parenchyma. With FC, in parallel ribcage information without delineating lung boundary was used to estimate the lung volume. Measurement of difference between FC and rib cage information based lung segmentation was calculated to indicate the presence of pathology. In second stage extracted texture-based feature were used to detect abnormal imaging pattern missed in first stage and novel neighbouring anatomy guided segmentation approach was used to include week texture information in segmented data. The quantitative results showed that this pathological lung segmentation method improved on current standards because of its high sensitivity and specificity and may have considerable potential to enhance the performance of routine clinical.

Hiram Madero Orozco1 et al [20] have presented a CAD system to detect and classify lung nodule as cancerous or noncancerous. Supervised extraction of Region of Interest (ROI) that is lung region was performed to eliminate the shape difference between different CT images with different scanner. ROI extraction is unique pre-processing task in this method without segmentation stage. Instead of segmentation, the images obtained from the ROI extraction were transformed from the spatial domain to the transformed domain. Discrete Wavelet Transformation (DWS) was applied on original image to extract the information. System performance was tested with 45 CT scan lung images from ELCAP and LIDC data set in which 23 images with nodules and 22 images without nodules. The results For the training 61 images were used among which 36 cancerous lung nodules and 22 without nodules. The result analysis showed that this methodology successfully classified as cancerous and noncancerous cell with sensitivity 90.90%, specificity 73.91%.

III. TABLE 1. SUMMARY OF VARIOUS LUNG PARENCHYMA SEGMENTATION AND NODULES IN LUNGS DETECTION TECHNIQUES

Sl.No	Study	Methods	Dataset	Result
1.	Younbum Lee [1]	Generic Algorithm	Helical CT images	Low accuracy with high False Positives (FP).
2.	Yoshinori Itai [2]	Active Contour Model	Multi Detector CT scanner image of size 512*512 size.	Low performance one minute to run on each CT slice image.
3.	Zhaoxue Chen [3]	Thresholding technique, fast flood filling technique, erosion operation and an area-filtering operation.	Multi Detector CT scanner images	Easy, efficient to segment ROI.
4.	Pei xiaomin Guo Hongyu Dai Jianping[4]	Combination of region growing and threshold method for segmentation. Convex hull operation and Ray casting for boundary correction.	Four-detector row CT scanner images	High accuracy
5.	Yang Liu [5]	Thresholding and Region growing algorithms, Semi-supervised learning method ADE-Co-Forest method.	DICOM files	High sensitivity and low false-positive

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6.	A Roozgard [6]	Median filter Morphological dilation and erosion filters, Watershed segmentation algorithm..	LIDC-IDRI dataset images	High sensitivity, specificity and accuracy
7.	Sheng Chen [7]	Virtual Dual Energy (VDE) to detect the nodules, Morphologic filtering technique	A publicly available database containing 140 nodules in 140 CXRs and 93 normal CXRs used for testing CADe scheme.	Sensitivity with 5 FPs/image: 85% and Sensitivity with 5 FPs/image FPs original CADe schemes: 78%.
8.	Kiran Thapaliya[8]	Bit-plane slicing, Connected component labeling and Boundary tracing algorithm	Many different types of CT images	High sensitivity and Specificity
9.	Awais Mansoor [9]	Fuzzy Connectedness(FC) image segmentation algorithm, ribcage information without delineating lung boundary to estimate the lung volume	Different types of CT images	High sensitivity and Specificity
10.	Hiram Madero Orozco [10]	Supervised extraction of Region of Interest and Discrete Wavelet Transformation of an original image to extract information	45 CT scan lung mages from ELCAP and LIDC data set in which 23 images with nodules and 22 images without nodules	Nodule classification as cancerous and noncancerous cell Sensitivity:90.90% Specificity:73.91%

IV. CONCLUSION

Early detection of lung cancer improves the survival rate. Effective CAD systems have been playing a vital role in assisting a radiologist for better diagnosis of lung cancer. In this paper a review of various approaches towards an automated detection of lung nodules, classifications are summarized. Survey reveals that CAD system to processes the 3D images (large amount of image slices) is required to improve the diagnosis processes. Designing the algorithm to detect Juxta-vascular nodules with less False Positive is more challengeable. Lung lesions detection and classification will remain as an active research area.

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