# A SURVEY ON LUNG SEGMENTATION TECHNIQUES

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**Abstract**

**Interstitial lung disease is one of the main treat to the health .Computer Tomography is used for assessment of interstitial lung disease .But sometimes it is difficult to visually interpret because of the crossing and overlapping of the vessels in the CT. There a vessel segmentation techniques is used for detecting lung disease Different techniques is available for lung segmentation for diagnosing lung disease. Vessel tree extraction is one of the challenging technique for several years and it is under open research. Automatic segmentation of vessel tree is one of the most important requirement for Computer Aided Diagnosis(CAD).In this paper we investigate lung vessel extraction and enhancement technique and present the capabilities of most important algorithms concerning lung vessel segmentation.**

## Introduction

.Lung disease is one of the leading cause of death. Some evidence suggest that early detection of lung disease may allow for timely therapeutic intervention which in turn result in a more favorable prognosis of the patients. Correct assessment especially accurate visualization and quantification of blood vessels, bronchi and all the tissues in lungs play an significant role in the detection of interstitial lung disease and other lung disease .But now adays the detection of lung disease is done by radiologist by using their naked eye to visualize the CT scan. But it is very difficult to distinguish the reticular pattern and ILD patterns in the lungs by using the naked eye. In clinical practice it is of great importance to be able to characterize the vascular tree for the detections of pulmonary emboli,pulmonary hypertension etc But it has found to be present to be an impossible task due to the following reason.

(i) It is difficult to determine boundaries of a vessel consistently, especially thin segments due to the partial volume effects and image noise

(ii)Volumetric lung scans of the adult human consist of more than 500 slices and the vascular tree in a bipodial fashion, rapidly branch as one tracks the vessels from their central to peripheral locations, with the full tree structure consisting of more than 23 generations

So a computerized diagnosis is essential for detecting the lung disease. Computer aided diagnosis(CAD)scheme for Multi Detector Computer Tomography are widely used to characterize quantify and detect numerous lung abnormalities..The aim of CAD system is to increase radiologist confidence and identify the extent and characterization of the type of present disease pattern.It can be used to detect numerous lung abnormalities such as focal abnormalities,pulmonary embolism etc.

So identifying vessel segments and diagnosing the lung disease is a major task .Another problem is the structure of the blood vessel. There will be thin segments and they are in low intensity. So enhancement of vessel is essential before segmentation .So the main steps in CAD system is vessel enhancement and segmentation of lung and vessels .Here an survey of different vessel segmentation techniques are done.

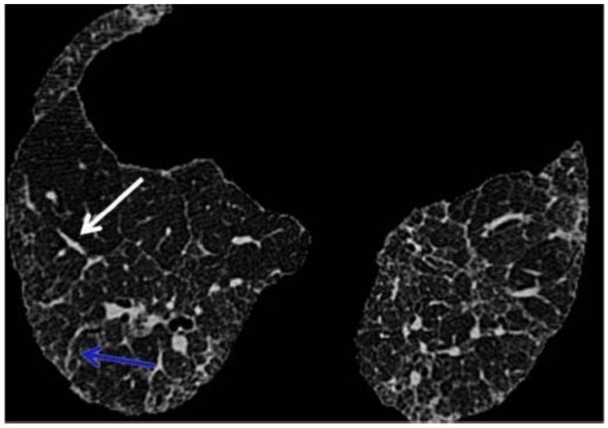

FIG (i) Similarity of reticular pattern (blue arrow)and vessel segments(white arrow)

## 3.LUNG SEGMENTATION

Before segmenting the vessels and nodule in the lungs the lung should be segmented. This is to extact lungs from fats ,muscles etc. The lung is surrounded by air walls and air sacs. So for segmenting the blood vessels it is essential to segment the lungs. Here describe different lung segmentation methods

In the algorithm proposed by Wang et al [6]several preprocessing are done.The preprocessing step include identify and estimates airways in each CT slice. A CT thresholding techniques[16] is used for intial lung estimate that include normal and mildly abnormal lung parenchyma .By the elimination of airways the tranchea , bronchi as well as some unwanted region were identified as airways.Here the method used is the trachea is identified on the seed point and traced the entire airways from an upper slice to a lower slice through the CT scan .The segmented airways were then removed from the CT images to prevent interference in lung segmentation. After removing airways from the CT images the next step is to estimation of initial lungs. A CT thresholding techniques is used[ 16].A 3D binary lung mask[6 ] is generated when the threshold was applied to the CT image.To remove the unwanted pixels apply a 2D connected component labeling algorithm[ 6]. This algorithm help to identify whether the two lungs connected or not. The next step of lung segmentation is to identification of abnormal lung regions. The severe ILD pattern have rich texture compared to surrounding soft tissue. Such texture information can be used to identify the abnormal lung regions. A 3D cooccurance matrix is employed to analyze the texture features of all pixels. The next step is postprocessing for filling the holes in the lungs. The holes were automatically identified and filled by 2D connected component labeling technique in each CT slice.

The method proposed by Kortifias et al mentions about lung field segmentation. It is done by two stage 3D LF segmentation technique[5]. Here a 3D histogram thresholding[12] lung field segmentation combined with edge highlighting wavelet preprocessing [12] step is done. By 3D histogram thresholding the lung can be divided into two segments ,normal lung parenchyma as one segment and fat ,muscle as other segment which is treated as backgroundsegment.Here edge highlightibg is done to reduce the noise in the CT scan.

In the method proposed by Kaftran et al lung [2]segmentation is done by region growing from a seed point is selected inside trachea. To remove the trachea and major airways from the lung mask a region growing process with adaptive threshold is started from the trachea seed.

In the algorithm proposed by Fieng Li et al 3D image processing and analysis techniques, trilinear interpolation technique [19] is employed.Here a thresholding technique is used to separate the lung region from other regions and background outside the body for each of the CT section .To include all jextapleural objects inside the lung region a starting point is considered ,scan counter clockwise all points on the entire contour one by one and find a point B with the condition [12]

(1) The distance between point A and B is less than 30mm .

(2) all the pixels is on astraight line AAB connecting points ‘A’ and ‘B’.

In the method proposed by shikata et al lung segmentation based on intensity thresholding [3] and 3D labeling is employed. The lung segmentation requires three seed points. They should be located in the left lung,, right lung and trachea. Both left and right lung are extracted by simple thresholding with a fixed value and 3Dlabelling with two seed points in the lungs

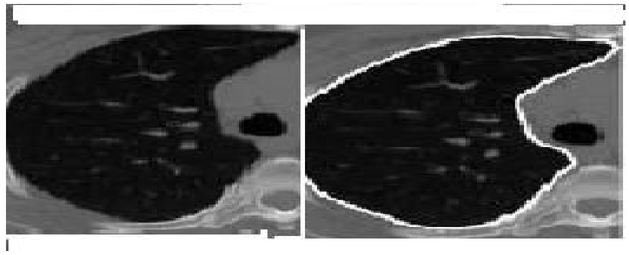

Fig 2 Lung segmentation

**3.VESSELENHANCEMENT**

Before segmenting the vessel it is necessary to enhance the vessel to distinguish different tube like structures,blob like structure and the blood vessels.

In the algorithm proposed by zhou et al[1] Multiscale 3D filters[21] are used to enhance local structures such as tissue boundaries ,cortices,vessels and nodules.Here a new filter is designed to enhance all vascular structures by using the eigenvalues of the hessian matrix.In conventional multiscale 3D filter they are limited to specific structures of interest and their filter response functions are defined explicitly.

Based on the characteristics of their eigenvalues of the hessian matrix a new multiscale response function R($\bar{r}$, $б_s$ ,$\lambda_1$, $\lambda_2$,$\lambda_3$ ) [1 ] is used .So all vascular structure including vessel bifurcation and to suppress non vessel structure such as the lymphoid tissue surrounding the vessel can be found by[1]

$$R(\bar{r}\ ;\ бs\ ;\lambda_1,\lambda_2,\lambda_3) = \begin{cases} \frac{((\lambda1|+\lambda2|)}{2}\exp\left(-\left|\frac{\lambda1}{\sqrt{\lambda1+\lambda2+}}-c\right|\right), \lambda1,\lambda2,\lambda3<0 \\ 0 \qquad otherwise \end{cases}$$

Where $\lambda_1$ ,$\lambda_2$,$\lambda_3$ are hessian eigen values at voxel $\bar{r}$=(x,y,z) in a 3D image .бs is the standard deviation of the Gaussian kernel at scale s and c is the constant.The constant *c* plays an important role in enhancement of both the tubular and the blob-like structures. The response $R_C$ of tubular structures can be approximated as

$$Rc=\frac{2|\lambda1|}{2}\exp\left(-\left|\frac{|\lambda1|}{\sqrt{2\lambda_1^2}}-c\right|\right)=\alpha|\lambda1|$$

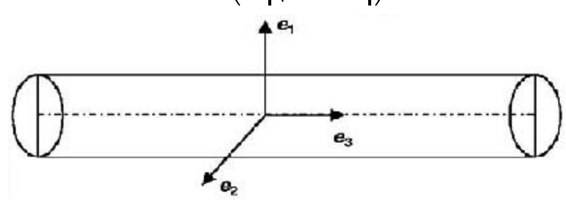


Fig 3: An ideal tubular structure and itseigenvectors

Schuldause et al [4]proposed an vessel enhancement technique by the selection of vessel branches that will be segmented This selection is done by the placement of manual seed points along the vessel branches A local adaptive contrast enhancement[4] is used to properly handle the inhomogenous distribution of the contrast agent within the vessel region .Here the idea is to place small overlying boxes along the vessel centerline and perform an intensity mapping of the pixel intensities with each box taking the lower pixel value of a overlying region .A hessian matrix is computed at each centerline point to get the two eigen vectors and eigenvalues which define the orientation of the box.

According to kaftran et al [2]a threshold based approach is used to segment the core pulmonary vascular tree.A lower threshold $T_2$ is applied and resulting components smaller than a minimum volume $V_{min}$ in size are eliminated[2]. Each component is reduced to one or more seed point by identifying local minima in a distant transformed image.

In kortifiates et al[5] in his work,a multiscale enhancement filter[21] is used for segmentation and visualization of curvilinear structure such as vessels in CT of the lung. The filter is based on eigen value analysis of the hessian matrix to capture characteristics of 3D tubular structure associated to the vessel tree .Original images are convolved with gaussian kernals of varying standard deviation enhancing local structure of specific sizes.

Shikhata et al [3] proposed vessel enhancement by a combination of the eigenvalue of the hessian matrix .Here enhancement of pulmonary vessel is done. Pulmonary vessels consist of segment with a wide range of radii. So multiscale approach[21] is done with radii information segmentation. Here thick vessels are easily extracted by a simple intensity based thresholding.

Frang Li[7] proposed the algorithm for image enhancement by the usage of three selective filters[7]. A multiscale selective filters to the original image is used for simultaneous enhancement of nodule and suppression of normal anatomic structure such as blood vessel.A thresholding techniques is used for separating nodule candidate from anatomic structure inside the lung region . A 3D connected component labeling technique[7] was employed for identifying all of the isolated objects

**4.VESSEL SEGMENTATION**

Frangi et al[7] proposed the vessel segmentation by extracting the features for each of the nodule candidate from the original image for the nodule,blood vessels and airways.The 18 features are extracted where

1.Six features based on nodule shape: effective diameter, degree of compactness and irregularity, determined in the initial and the grown nodule regions.

2.Twelve features based on voxel value: mean and standard deviation of voxel values inside the grown region, each extracted from the original CT image, from the nodule-, blood vessel-, and airway wall-enhanced images and from the two images for the shape index and curvedness

The rule-based classifier[7] probably has been the most frequently used one since the early days of development of various CAD schemes, including the detection and diagnosis of breast masses and microcalcifications,lungnodules,colonicpolyps , heart disease,mesothelial lesions and bone disease. A rule in CAD schemes typically consists of two steps, i.e., selection of a feature and selection of a cutoff threshold.

Vessel segmentation is done by Zhou et al [1]by constructing voxel value histogram of a typical CTPA image slice of which the voxel values are transformed to 0-4095 to facilitate image processing .A multistage adaptive segmentation method was developed to cluster voxels into soft tissues, chest walls ,lung regions. A n expected maximization algorithm [22]is used for estimation of missing model paremeters. It can also be defined as a probabilistic counterpart to fuzzy clustering

Korfiatis et al [5] apply an expectation maximization algorithm on filter response in order to identify the voxels with high response associated with tubular structure. A supervised classification scheme based on SVM classifier[14][15] and 3D cooccurance texture feature was used to differentiate between vessel tree segments and reticular patterns. A Gray level cooccurance matrix[5] are used to extract the texture features .Here 13 features are extracted here and the feature are given to the SVM classifier.SVM classiifers[14] are trained to be able to distinguish the lung disease pattern and the reticular patterns

Kaftran et al[2] propose an fuzzy segmentation step which creates an improved segmentation using the original masked dataalong with the identified seed points.A fuzzy connectedness algorithm[19] is used to determine whether a voxel belong to the vascular tree. The main principle used here is an object O with its seed point $s_i$ € [0,n-1] and the background B are separated by dividing the set ofvoxels presentin theimage volume in such a way that the”belongingness” of each object voxel to the seedpoint is larger than the “belongingness” of each background voxel.

According to schuldhair[4] as the first step in segmentation method,a binary threshold filter[5] is applied on the contrast enhanced image to get a binary mask. As some artifacts appear in the vicinity of the vessels, to remove it the binary image is skeletonized by a medical axis based on skeletonisation approach. Each skeleton part has to exhibit a mininmum number of points which are defined heuristically

According to shikata et al [3]the vessels are segmented using intensity thresholding.Thresholding with a fixed value is applied to obtain thick segment and a discrete distance transform is applied to estimate an appropriate radius r[3]

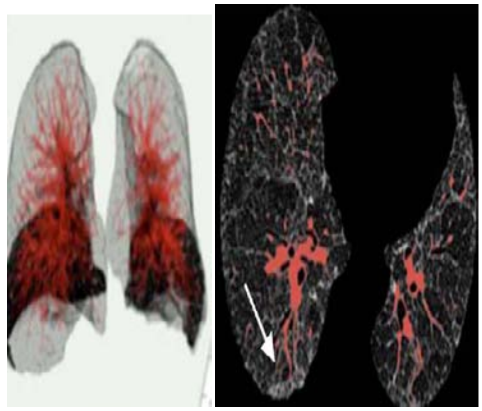

Fig 4: Vessel Segmentation in korfiatis algorithm

## 5. A BRIEF COMPARISON OF LUNG SEGMENTATION TECHNIQUE

| Algorithm | Year | Input | Multiscale | Segmentation technique | Preprocessing | Enhancement Technique |
|---|---|---|---|---|---|---|
| Chan Zhou | 2007 | CT scan | Yes | Multistage adaption | No | Multiscale filter using hessian matrix |
| Wang | 2007 | CT scan | Yes | CTvalue thresholding | Yes | Multiscale filter using hessian matrix |
| Fieng Li | 2005 | CT scan | Yes | Region growing | No | Selective filters multiscale using hessian matrix |
| Shikata | 2009 | CT scan | Yes | Intensity thresholding | No | Multiscale filter using hessian matrix |
| Kortifias | 2011 | CT Scan | Yes | 3D histogram thresholding | No | Multiscale filter using hessian matrix |
| Kaftran | 2008 | CT scan | Yes | Fuzzy connectedness | No | No Enhanceent |
| Schuldause | 2011 | X ray | No | Region growing | No | Local adaptive contrast technique |

## 6.CONCLUSION

In this paper we have tried to cover both early and recent literature related to lung vessel segmentation algorithms and techniques. The aim was to introduce

the current segmentation techniques.

Accuracy of the segmentation process is crucial according to the nature of the work and lead

to more precise and repeat all radiologist diagnostics system.Accuracy can be incoorparating a priori information on vessel anatomy and make use of high

level knowledge guide for the segmentation algorithm. Even though expert knowledge and

guidance is essential in segmentation system,shear volume of the medical image data require more automatic system to reduce the workload .

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