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Integrated Atlas Based Localisation Features in Lungs Images

Mr.N.Bensingh,
PG Student, Department of Computer Science and Engineering
MNSK Engineering College, Pudukottai District, India.
(bensingh07@gmail.com) (07502750209)

Abstract:
Segmentation of the pulmonary lobes is relevant in clinical practice and particularly challenging for cases with severe diseases or incomplete fissures. In this work, an automated segmentation approach is presented that performs a transformation on computed tomography (CT) scans to subdivide the lungs into lobes. Content-based image retrieval has been a major research area with major focus on features extraction, due to its impact on image retrieval performance. When applying this in the medical field, required different feature extraction method that integrate some domain specific knowledge for effective image retrieval. Here a novel method called atlas based segmentation is proposed. Atlas methods usually require the use of image registration in order to align the atlas image or images to a new, unseen image. This method provides complementary information from past cases with confirmed diagnoses, to lung tissue classification and quantification in CT images. The system exploits the location of the pathological lung tissue and allows significant improvement in terms of early retrieval precision when compared to the approach based on global features only.
KEYWORDS: Computed Tomography, Segmentation, Atlas based segmentation

I. Introduction:

Segmentation of pulmonary lobes from computed tomography (CT) images is a precursor to most pulmonary image analysis applications. Computed tomography (CT) for the body has been available since 1975. Medical Image Processing is currently a hot research area in medicine and it is believed that they will receive extensive application to biomedical systems in the next few years.

The human lungs are subdivided into five lobes that are separated by visceral pleura called pulmonary fissure. There are three lobes in the right lung, namely upper, middle, and lower lobe. The right upper and right middle lobe are divided by the right minor fissure whereas the right major fissure delimits the lower lobe from the rest of the lung. In the left lung there are only two lobes, the upper and the lower lobe, that are divided by the left major fissure. The characteristic of the pulmonary lobes are separated supply branches for both vessels and airways. Lung lobe segmentation is relevant in clinical applications particularly for treatment planning. The location and distribution of pulmonary diseases are important parameters for the selection of a suitable treatment.

Computed tomography (CT) allows visualization of the lungs within a few seconds.

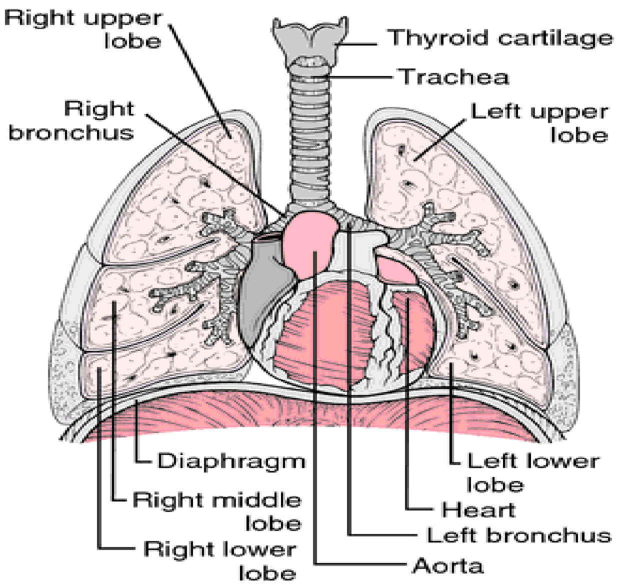


Fig 1. Lung Anatomy

Since typical scans with high anatomical details contain over 400 slices with sub millimetre resolution for each direction, manual segmentation is time consuming and there is demand for automatic lung lobe segmentation methods. The segmentation of pulmonary lobes is challenging because of anatomical variation and incomplete fissures. On the one hand, pathologies can deform the lobes and make the fissures unrecognizable. Water shed methods are generally time-consuming; segmentation of one case took 2 hour on average.

Another disadvantage of this approach was that scans with lobar shapes not represented in the data set were unlikely to be segmented correctly. Any computer system that analyzes the lungs and does not work on manually delineated regions of interest must incorporate automatic lung segmentation.

II. Related Work:

Lung Segmentations:

The pulmonary segments are a reference system for radiologists, pulmonologists, and surgeons to indicate the position of lesions in the lungs. This allows a lobe based CT parameter extraction and thus a more accurate prediction of post operative lung function in case of a lobar resection, which is the standard treatment for early stage lung diseases. Automatic lung segmentation starts from different combined image segmentation and processing techniques. It starts with iterative thresholding and then enhances the fissure inside the lungs. We can use two different methods for lung segmentation one is edge tracking and another one is region filling.

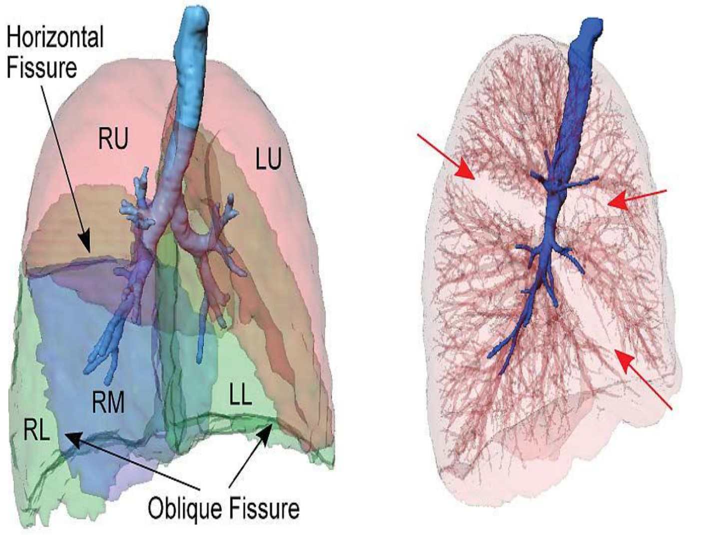
Based on the assumption that there are usually no major vessels at the lobar boundaries, the distance to the pulmonary vasculature is a suitable feature to detect lobar boundaries. To quantify the absence of vessels at the lobar boundaries, a coarse segmentation of the pulmonary vasculature is sufficient. There is high contrast between blood vessels and lung parenchyma that enables a coarse segmentation of the pulmonary blood vessels by thresholding the data inside the lung region

The goal is to include as many vessels as possible but exclude fissures and other dense structures. As the lung is essentially a bag of air in the body, it shows up as a dark region in CT scans. This contrast between lung and surrounding tissues forms the basis for the majority of the segmentation schemes. Segmentation is often a necessary first step to computer analysis.

In CT of the lungs, the various anatomical entities that can require segmentation are the lungs themselves, the airways, the vessels and the lung lobes.

Segmentation of Airways

The airways exhibit a tree structure (the trachea bronchial tree) of roughly cylindrical branches of decreasing radius.



(a) Lung lobes. (b) Vessel and bronchi tree.

Fig 2. Lung lobes, vessels and bronchi tree

The trachea bifurcates into the left and right main bronchus. These bronchi repeatedly bifurcate (or trifurcate) into smaller bronchi. The bronchial lumen is (normally) filled with air, surrounded by the bronchial wall which has a relatively high CT value.

Segmentation of Vessels

Each lung contains an arterial and a venous vessel tree. Where the pulmonary arteries and veins enter the lungs, their diameter can be up to 30 mm. As they branch, vessel diameters decrease. On a normal CT scan vessels can be seen up to 5–10 mm from the pleura. The arteries follow the course of the bronchial tree (when the bronchial wall is thickened, bronchus and artery have the appearance of a signet ring).

Automatic Segmentation

The diagram shows the pulmonary lobes from chest ct scans based on fissures, vessels, and bronchi.

1. Lobe Segmentation and Post processing:

To obtain a lobe segmentation from the cost image Down sampling of the cost image to a resolution of 1.5 mm x 1.5 mm x 1.5 mm is applied to reduce calculation time.

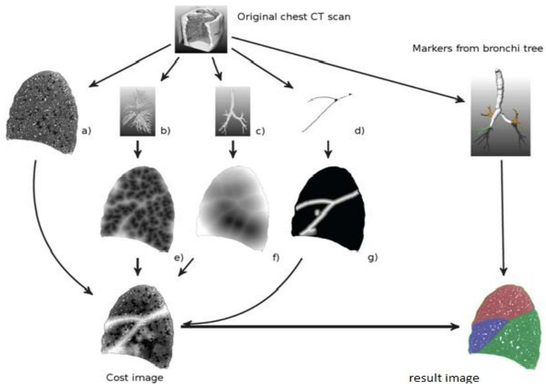


Fig 3. Automatic Lung segmentation

The applied technique separates regions with local maxima in between and can be used with an arbitrary number of markers. The borders between the obtained lobes after the watershed segmentation are not always smooth due to local variations in the cost image. Two majority filters with different kernel sizes (3 x 3 x 3 and 5 x 5x 1) are applied in a row to smooth the boundaries. The label value that occurs most often under the kernel is set to the voxel. To obtain the lobe segmentation on the original resolution, the segmentation results are up sampled using nearest neighbour interpolation.

2. Fissure Detection

The threshold image contains fissures, other lung tissue structures and isolated voxels representing “noise”. A traditional image smoothing operation (e.g., a Gaussian filter) cannot be applied to the images because the fissures may be “smoothed out” together with image “noise”. To overcome this difficulty, we applied a statistical approach to extract the pulmonary fissures in three-dimensional geometric space. This approach can distinguish between fissure surface (curved plane) and isolated small regions with random normal vectors (orientations).

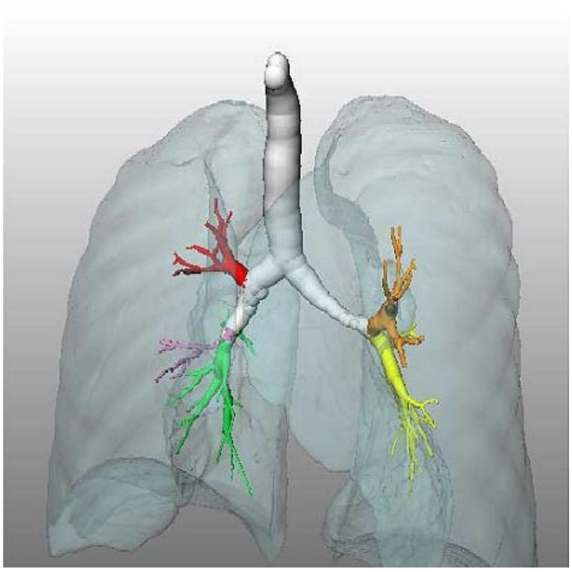


Fig 4. Analysed airway tree

Automatic Segmentation:

There are different research alludes to different concepts of automatic segmentation. Computed tomography (CT) offers higher resolution and faster acquisition times. This has resulted in the opportunity to detect small lung nodules, which may represent lung cancers at earlier and potentially more curable stages. A computerized method for automated identification of small lung nodules on multi slice CT (MSCT) images is proposed in [1]. If a nodule is attached to a blood vessel and there is no density between the nodule and the vessel at their contact points, the nodule may not be able to be detected by this algorithm.

A fully automatic lobe segmentation approach based on watershed transformation approach is given in [2]. The quality of lobe segmentation depends on a good bronchi and vessel tree segmentation. A novel pulmonary nodule detection method based on hierarchical block classification is in [3]. Image retrieval is not included here became the disadvantage of this method.

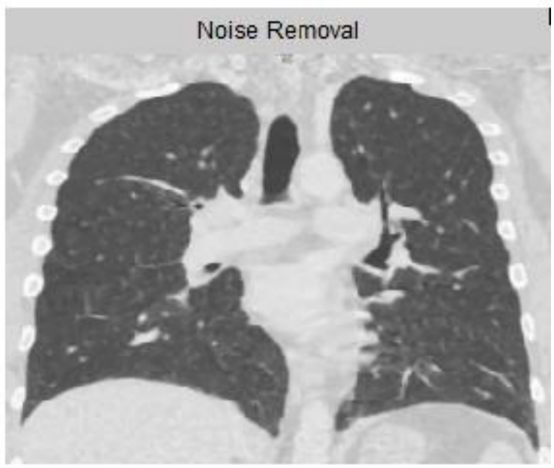
Computed tomography (CT) technology allows for near isotropic, submillimeter resolution acquisition of the complete chest in a single breath hold. These thin-slice chest scans have become indispensable in thoracic radiology, but have also substantially increased the data load for radiologists. Automating the analysis of such data is, therefore, a necessity and this has created a rapidly developing research area in medical imaging. Pre processing is done on the CT image of lung for removal of noise.

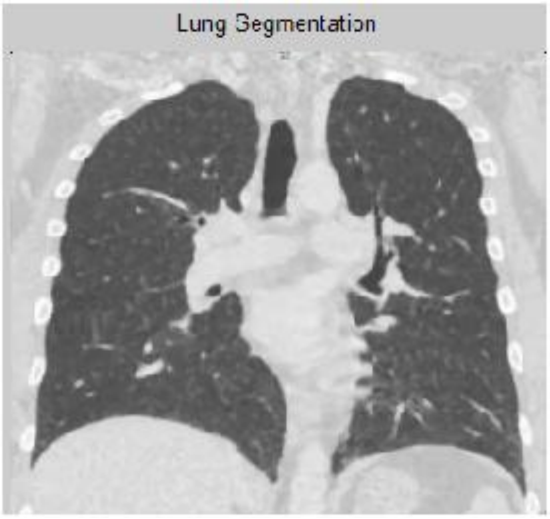
A fuzzy filter is presented for the noise reduction of medical images corrupted with additive noise. The filter operation involves two stages. The first stage computes a fuzzy derivative for eight different directions. The second stage uses these fuzzy derivatives to perform smoothing with the fuzzification and De fuzzification operations along by weighting the contributions of neighbouring pixel values. Both stages are based on fuzzy rules [5]. The fuzzy filter is having high data set to process while compared to that of other filters.

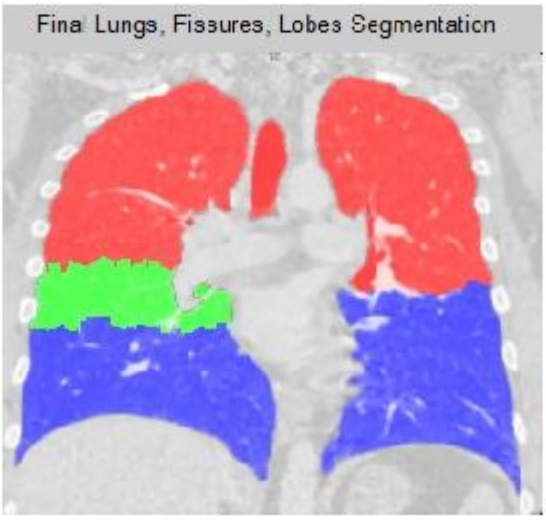
Since the lobes are mostly independent anatomic compartments of the lungs, they play a major role in diagnosis and therapy of lung diseases. The exact localization of the lobe-separating fissures in CT images often represents a non-trivial task even for experts. Therefore, a lung lobe segmentation method suitable to work robustly under clinical conditions must take advantage of additional anatomic information. Due to the absence of larger blood vessels in the vicinity of the fissures, a distance transform performed on a previously generated vessel mask allows a reliable estimation of the boundaries even in cases where the fissures themselves are invisible. To make use of image regions with visible fissures, we linearly combine the original data with the distance map. The segmentation itself is performed on the combined image using an interactive 3D watershed algorithm which allows an iterative refinement of the results as in [6]. It requires large data set to process. Image retrieval technique is not included here. Lung nodule detection in ct images using thresholding and morphological operations [7] which does not included the code to identify the effective features and is not suited for image retrieval system.

Segmentation of the pulmonary lobes is relevant in clinical practice and particularly challenging for cases with severe diseases or incomplete fissures. In this work, an automated segmentation approach is presented that performs a marker-based watershed transformation on computed tomography (CT) scans to subdivide the lungs into lobes. When applying this in the medical field, required different feature extraction method that integrate some domain specific knowledge for effective image retrieval. Here a novel method called atlas based segmentation is proposed. Atlas methods usually require the use of image registration in order to align the atlas image or images to a new, unseen image. This method provides complementary information from past cases with confirmed diagnoses, to lung tissue classification and quantification in CT images. The system exploits the location of the pathological lung tissue and allows significant improvement in terms of early retrieval precision when compared to the approach based on global features only.

Results:







Conclusion and future work:

Computed tomography (CT) allows visualization of the lungs within a few seconds. Since typical scans with high anatomical details contain over 400 slices with sub millimetre resolution for each direction, manual segmentation is time consuming and there is demand for automatic lung lobe segmentation methods. The segmentation of pulmonary lobes is challenging because of anatomical variation and incomplete fissures. On the one hand, pathologies can deform the lobes and make the fissures unrecognizable. Water shed methods are generally time-consuming; segmentation of one case took 2 hour on average. Another disadvantage of this approach was that scans with lobar shapes not represented in the data set were unlikely to be segmented correctly. Any computer system that analyzes the lungs and does not work on manually delineated regions of interest must incorporate automatic lung segmentation

A traditional image smoothing operation cannot be applied to the images because the fissures may be “smoothed out” together with image “noise”. To overcome this difficulty, we applied a statistical approach to extract the pulmonary fissures in three-dimensional geometric space. This approach can distinguish between fissure surface (curved plane) and isolated small regions with random normal vectors (orientations). Fissure enhancement consists of canny edge detection algorithm and followed by three morphological operations namely dilation, closing and thinning. The lobe segmentation can be obtained from the cost image Down sampling of the cost image to a resolution of 1.5 mm x 1.5 mm x 1.5 mm is applied to reduce calculation time.

This method is generally time-consuming; segmentation of one case took 2 hour on average, to overcome this time delay a fully automated reliable and accurate results for low resolution CT images by atlas based lung segmentation method with minimum data set and that should include the method for image retrieval system.

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