An Automatic Method for Segmenting Lungs

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Abstract— Image segmentation is an important task for image understanding and analysis. Image segmentation can be applied in medical field such as diagnosing the diseases. In recent times, Computed Tomography (CT) is the most effectively method used for detecting lung cancer and other types of diseases associated with lung. Segmentation of lung is an analysis the lung deeply and checks for whether it contains any diseases or not. Nodule is an early stage of lung cancer i.e., mass in the lung. Lung segmentation is complex due to presence of juxta-pleural nodule and blood vessels. So this drawback is overcome by a fully automated method of lung segmentation is used. In this paper, segmentation scheme consist of three stages: pre-processing, lung extraction, lung identification. The goal of pre-processing is reduce the noise from CT image of lung. Second stage is lung extraction for removing fat, tissues and artifacts of patients. Third stage is lung identification for detecting lung by using Fuzzy C Means algorithm and also removes the airways. This method is mostly used for identifying the lung nodules as well as other diseases.

KEYWORDS— LUNG, IMAGE SEGMENTATION, FUZZY C MEANS, JUXTAPLEURAL, NODULE, BLOOD VESSELS, COMPUTED TOMOGRAPHY

1. INTRODUCTION

Image segmentation is an important image processing step, and it is used everywhere if we want to analyze what is inside the image. Image segmentation; basically provide the meaningful objects of the image [1]. In recent years image segmentation has been extensively applied in medical field for diagnosing the diseases. In case of medical image segmentation the aim is to: study anatomical structure, identify Region of Interest i.e. locate tumor, lesion and other abnormalities, measure tissue volume to measure growth of tumor (also decrease in size of tumor with treatment), help in treatment planning prior to radiation therapy; in radiation dose calculation, measuring tumor volume and its response to therapy, detection of micro calcification on mammograms automated classification of blood cells, studying brain development, image registration, etc [2].

Medical imaging techniques often use anatomic structures as a 'guide' to perform segmentation tasks. Such techniques typically require some form of expert human supervision to provide accurate and consistent identification of anatomic structures of interest. Automatic segmentation of medical images is a difficult task as medical images are complex in nature and rarely have any simple linear feature. Further, the output of segmentation algorithm is affected due to partial volume effect, intensity inhomogeneity, presence of artifacts, and closeness in gray level of different soft tissue. Artifacts present in MR and CT images can be divided into three categories on the basis of image processing technique needed to rectify them: artifacts needing appropriate filtering technique, artifacts needing appropriate image restoration techniques for example motion artifacts and artifacts needing specific algorithm are; partial volume, intensity inhomogeneity.

One of the medical imaging segmentation is lung segmentation. The lungs are a pair of spongy, air-filled organs located on either side of the chest (thorax). A pulmonary nodule is a small round or oval-shaped growth in the lung. It is sometimes also called a spot on the lung or a coin lesion. Pulmonary nodules are generally smaller than 3 centimeters in diameter. If the growth is larger than that, it is known as a pulmonary mass. A mass is more likely to represent a cancer than is a nodule. Computed Tomography (CT) based Computer-Aided Detection (CAD) is the most commonly used diagnosis technique due to its high sensitivity of small pulmonary nodules and flexible representation of the human thorax.

CT or Computer Axial Tomography, uses special X-ray tube to obtain image data from different angles around the body, and then uses computer processing of the data to show a cross-section of body tissues and organs. Some of the basic ideas underlying CT are reconstruction from projections that means that the patient data is getting measured at many positions and angles. CT modalities can show various types of tissues, lung, soft tissue and bones, and using specialized equipment and expertise to create and interpret CT scans of the body, radiologists can more easily diagnose tumor, cancer or other lesion, and to measure its size, precise location, and the extent of the tumor's involvement with other nearby tissue. The images received from a CT scanner can reveal some soft tissue and other structures that cannot even be seen in conventional X-rays. Computerized Tomography scan an image provides detailed, cross sectional views of all types of tissues in the human body. It is used for diagnosing various cancers like lung, liver etc and also measure size, location of tumor and extent of damage to the nearby tissues [12]. CT images shows very small as well as neighboring tissues such as muscle and blood vessels. Fig.1 shows CT image of lung.

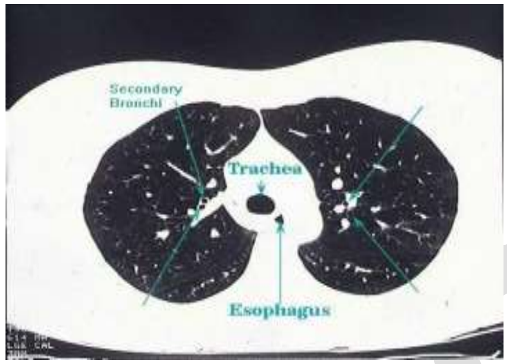

Fig.1 CT scan image of lung

In this paper, propose automated lung segmentation in CT images for deeply analyzing any diseases in the lung. This method is beginning with preprocessing by using anisotropic filter for remove noise without blurring edges and then extracts the lung parenchyma and airways region from CT image. The lung region is identified by using Fuzzy C Means clustering.

This paper is organized as follows: In section 2 includes the related works. The proposed method is explained which includes 3 stages in section 3. Ultimately section 4 concludes the proposed work.

2. RELATED WORKS

In the past, various techniques are used to segment the lung. Manual segmentation of lung images is extremely times consuming for users, labor intensive and prone to human errors [3]. Armato et al. showed that 5–17% of the lung nodules in their test data were missed due to the inaccurate pre-processing segmentation, depending on whether or not the segmentation algorithm was adapted specifically to the nodule detection task [4].

Pu et al. proposed an adaptive border marching algorithm (ABM) to correct the lung boundary. The problem with ABM is that the border marching with fixed threshold may fail in some slices. For example, the lung lobe containing juxtapleural nodule needs a smaller threshold while the lung lobe without juxtapleural nodule and containing convex region requires higher threshold [5].

Giger et al. presented the computerized detection of pulmonary nodules on CT scans. The rolling ball algorithm (RBA) is one of the early used methods to ameliorate the lung contour that is determined by thresholding. The rolling ball is a circular filter with a predefined radius [3]. A rolling ball algorithm was applied to the lung contours segmented by thresholding to avoid the loss of the juxtapleural nodules. The extremely varied sizes of juxtapleural nodules, it is difficult to select a proper rolling ball radius that is suitable for all juxtapleural nodules [4].

Sluimer et al propose a segmentation-by-registration scheme is used to segment and correct the lung boundary. This type of methods works well on the lungs even containing (substantial) pathologic abnormalities. But the creation of a model used in registration is not a trivial issue due to the high density pathologies in varying degrees of severity [6]. Although radiologists are able to identify the lung boundary slice by slice, it is extremely time-consuming and prone to intra- and inter-observer variability [7].

3. PROPOSED METHOD

Segmentation of lung is very difficult due to some fat, bone, tissues and other artifact. So this drawback is rectified by an automated lung segmentation is proposed.

In proposed system consists of three main stages: Image pre-processing, Lung extraction, Lung identification. Fig 2 shows the overview of proposed system.

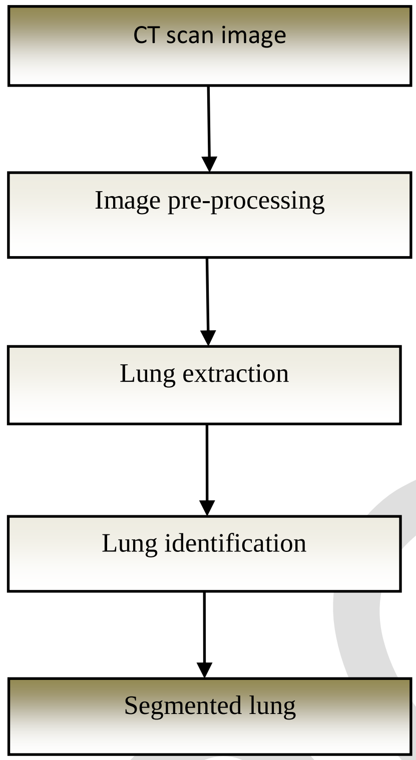

Fig.2 Overview of Proposed System

A. Image Pre-Processing

The first step was to convert the image to gray scale. So by converting the image to gray scale, the processing time is reduced and a faster algorithm is produced [2]. The goal of pre-processing is to reduce image noise. Nonlinear anisotropic diffusion filtering is an implicit edge detection step into the filtering process. This encourages intra-region smoothing and preserves the inter-region edge [9, 11].

B. Lung Extraction

In CT scan image contain two kinds of voxels. One is body voxels (high intensity pixels) such as ribs, fat and chest wall structures and another voxels is non-body voxels (low intensity pixels) such as air-filled region. Each voxels have CT number or Hounsfield unit [HU]. The Hounsfield unit (HU) scale is a linear transformation of the linear attenuation coefficient of the original attenuation coefficient. CT number is quantitative scale for describing radio-density. Radio-density of air at STP is -1000HU, lung tissue range from -910HU to -500HU and chest wall, blood vessels, bone which have above -500HU. Fig 3 shows values of Hounsfield values or CT number of each region in CT scan image. The main goal of this step is removal of chest wall, bone, fat for future segmentation. This is achieved by generating histogram of CT image and calculates threshold value by taking mean value of two peaks for Binarize the images. Binary image are generated from input gray-level CT image by select threshold from histogram of lung, a better method than the conventional thresholding algorithm, in which the threshold is simply chosen as the minimum between the two maxima of the gray level histogram. The image histogram is initially divided into two parts using a starting threshold value, which can be for example half the maximum of the dynamic range of the current image, or the conventional threshold value just described. The background removed image contains holes in Lung lobe; those are either nodules or vessels. It is important to include them in the Lung lobe region. These holes are filled using the hole filling morphological operators. Fig 4 shows the histogram of pixels in CT images in which fats, bone and muscles have high HU value than lung parenchyma and airway.

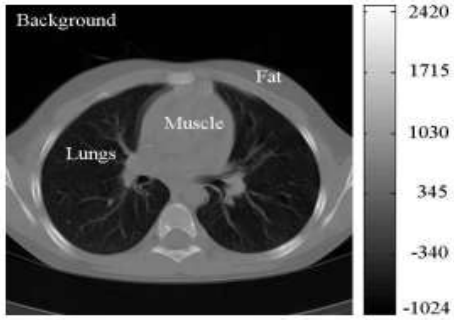

Fig.3 HU values of CT image

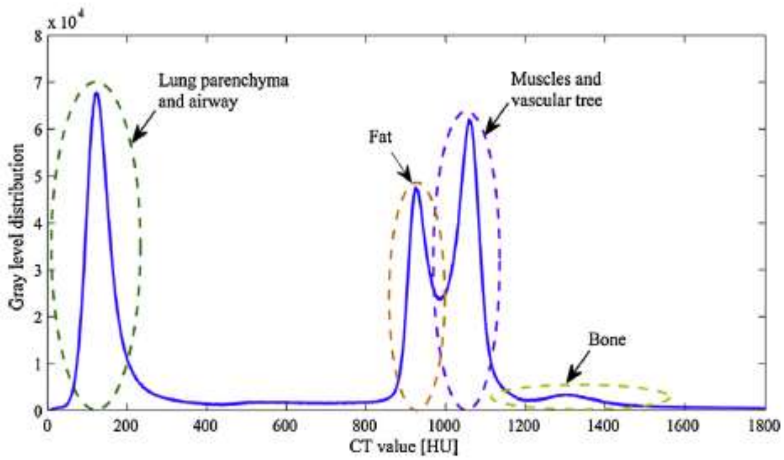

Fig.4 Histogram of pixels in CT images

C. Lung Identification

1. Lung parenchyma and airways are detection

In hard clustering, data is divided into distinct clusters, where each data element belongs to exactly one cluster. In fuzzy clustering, data elements can belong to more than one cluster, and associated with each element is a set of membership levels. These indicate the strength of the association between that data element and a particular cluster. Fuzzy clustering is a process of assigning these membership levels, and then using them to assign data elements to one or more clusters [10].

Fuzzy segmentation has been favored over hard segmentation in some medical image applications since partial volume effects and image noise reduce the accuracy of hard segmentation. To cope with the limits of hard segmentation, a fuzzy c-means (FCM) clustering method [11] is employed to classify pixels into several tissue categories.

In FCM method, a set of tissue classes is first determined. Each pixel is then classified by its membership values of tissue classes according to its intensity. Each tissue class has a centroid. FCM can be written as the minimization of the weighted inter-class sum of the squared error objective function J_{FCM}

$$J_{FCM} = \sum_{c=1}^{C} \sum_{j=1}^{J} u_{jc}^{2} \left\| I_j - v_c \right\|^2 \quad (1)$$

where v_c is the centroid of class c and C is the total number of tissue classes; u_{jc} is the membership value of pixel j for class c and requires $u_{jc} \in [0,1]$ subject to $\sum_{c=1}^{C} u_{jc} = 1$; J is the total number pixels in the image and I_j is the image intensity at the position j.

The objective function is minimized when a large membership is assigned to pixel close to the centroid of a class and a small membership value is assigned to a pixel far away from the centroid. This is a nonlinear problem and can be solved iteratively. During each iteration, a new set of membership functions and class centroids are computed. The following steps describe the FCM method:

1. Set the initial values for class centroids, $v_c, c = 1, \dots. C$.
2. Compute the membership values

$$u_{jc} = \frac{\|I_j - v_c\|^{-2}}{\sum_{l=1}^{C} \|I_j - v_l\|^{-2}} \tag{2}$$

3. Compute the new centroid for each class

$$v_c = \frac{\sum_{j=1}^{J} u_{jc}^2 I_j}{\sum_{j=1}^{J} u_{jc}^2} \tag{3}$$

4. Repeat steps (2) and (3) until the algorithm converges. Convergence is reached when the maximum changes over all centroid between two iterations are less than a predefined small threshold value ∈(0.001 in current algorithm).

2. Large Airways Elimination

After detecting lung parenchyma region, next step to remove the main trachea and bronchus by region growing algorithm [11, 13]. A seed pixel is selected from centroid location of trachea region. Then compare between seed pixel and neighboring pixel if it is similar, then grows seed pixels towards to boundary of lung. This procedure continues until the stopping criterion is reached.

3. Left and Right Lung Separation

After the large airways elimination, then analyze the remaining connected components slice by slice [10]. This results either in one (both left and right lungs merge together) or two (both two lungs are separated) by using erosion [8]. Erosion is the dual of dilation. The erosion of object X with a structuring element SE is denoted as:

$$Y = X \Theta d . SE \tag{4}$$

Also here the structuring element is defined by the connectivity, which can be 4 or 8- connected for 2D images. If the central pixel in the 3×3 neighborhood is an object pixel and at least one of the pixels in the neighborhood is a non-object pixel, the central pixel becomes a non-object pixel.

The juxtapleural nodules tend to be excluded from the lung segmentation result in the previous step due to its density that is similar with thorax; moreover, high density pulmonary vessels are also ruled out from segmentation result which gives rise to indentations and salience in the lung boundary near the mediastinum. By using Gaussian filter this problems can be solved [11].

Finally, the output image is segmented image of lung. This output can be used for further analysis as well as finding pathologies of lung.

4. CONCLUSION

This paper presents an efficient automated approach for segmenting lung on CT images. Automated segmentation of lung on CT image is more accuracy than manual segmentation of lung as well as easy to segment and studying deeply each part of segmented images. The CT images are preprocessing, extracted and identification. The first is preprocessing by using anisotropic filter. The advantages of anisotropic filter are to remove the noise without blurring edges. It also smoothes intra-region and preserve inter-region. The second stage is lung extraction which helps us to remove artifacts for further segmentation. The third stage is lung identification in which lung is extracted for deeply analysis by using FCM. Future work will be correcting the lung contour and detected the lung nodule.

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