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Automatic Lobar Segmentation Algorithm for Pulmonary Lobes from Chest Ct Scans Based On Fissures and Blood Vessels

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ABSTRACT: Lobewise examination of the pulmonary parenchyma is of scientific significance designed for make a diagnosis and monitoring of pulmonary diseases pathologies becomes important . In medical applications the segmentation of the lung lobe segmentation becomes very important to identify the lung lobes and make a treatment for medical applications of particular patient. Image segmentation is the procedure in which the original image is partitioned into homogeneous regions and plays an important role in medical image processing. In lung lobe segmentation methods segmentation of pulmonary becomes a very difficult and challenging issues for CT images, since changeable reflection resolution, noise and feature obtained through dissimilar CT scanners. Furthermore, difference in examination is numerous, and imperfect fracture is frequent, particularly in rigorous lung disease cases. In recent work automatic lung lobe segmentation the segmentation is performed based on the watershed transformation with the intention of obtain an examination of lobar airways and vasculature addicted to description .But segmentation result are fused based on the Euclidean distance measure which becomes less results, in order to solve this issue in this work, an automated novel lung lobe segmentation method is applied to computed tomography (CT) which separates the lung lobes into pulmonary fissure , Vessel and voxles. Measure of medium truth degree (MMTD) is employed for automatic segmentation of lung lobe. MMTD measure the similarity between the original pixels and make use of correlation of the pixel. In initial stage, the lobar markers are determined by the calculation of labeled bronchial tree. In initial stage of the work the pulmonary vessels are detected based on MMTD. In the second step of the work pulmonary fissures is segmented based on the fissure enhancement where eigen values of is determined from Hessian matrix . In third stage two pre-processing steps is applied such as Gaussian smoothening and bronchial tree . Gaussian smoothening is mainly performed to reduce the noises in the input image samples. The bronchial tree is mainly applied to enhance the quality of the input image samples. Cost image is calculated through mixing the information of fissures, bronchi, and pulmonary vessels distance results. The experimentation results of the proposed MMTD- Lobar segmentation is compared with earlier methods and it applied for 20 CT scans through rejection or mild disease.

KEYWORDS: Lung lobes, Computed tomography (CT) , pulmonary fissures, segmentation, measure based on the measure of medium truth degree (MMTD).

I. INTRODUCTION

In general the human lungs are categorized into several lobes, among them all categories five lobes with the intention of are divided through visceral pleura which is called as pulmonary fissure. This pulmonary fissure consists of three major right lobes such as higher, center, and lower lobe. The right higher and right center lobe are separated by means of the precise minute fissure at the same time as the right most important fissure restrict the minor lobe beginning the relax of the lung. The remaining two lobes are categorized under left major fissure (see Fig. 1a). A distinguishing of the pulmonary lobes are divided provide branches designed for together vessels and airways (see Fig.1b).

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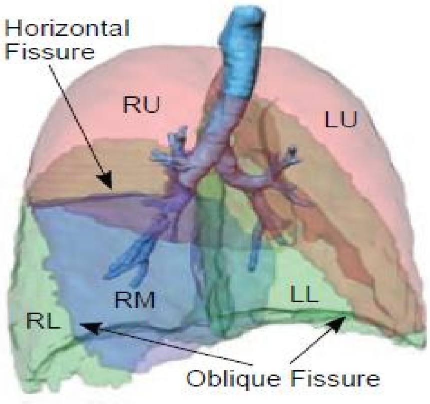

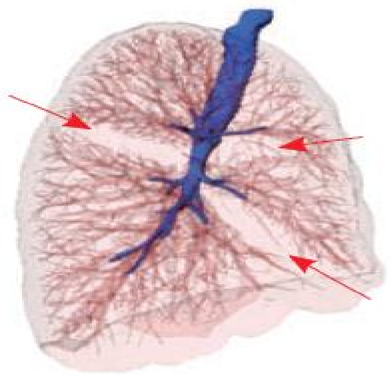

(a) Lung lobes (b) Vessel and bronchi tree

Fig. 1: Renderings of the anatomy of the lungs a) shows a rendering of the lungs subdivided into the right upper (RU), right middle (RM), right lower (RL), left upper (LU), and left lower (LL) lobe. b) shows a rendering of the vessels (red) and bronchi (blue) tree of the right lung. There are no major supply branches at the lobar boundaries (arrows).

In medical applications the segmentation of the lung lobe segmentation becomes very important to identify the lung lobes and make a treatment for medical applications of particular patient. Since identify and recognize the specific location and division of pulmonary diseases are significant constraint on behalf of the assortment of an appropriate action. In the neighborhood distributed emphysema is able to be delicacy further successful through lobar quantity resection than equivalently distributed emphysema [1]. One more purpose is continuously monitoring of pulmonary diseases such as emphysema or fibrosis. So the lobe-wise examination demonstrates the efficient examination of lung segmentation for identification of emphysema or fibrosis in medical applications and images. Among them several number of medical images, Computed tomography (CT) permit revelation of the lungs inside a few seconds. Because distinctive scans through elevated anatomical details enclose over 400 segments through submillimeter motion used for each way, but the manual segmentation methods is more labor-intensive, time consuming .To manage this issue automatic image segmentation is required for segmentation of lung lobe images.

In general and manual segmentation methods the segmentation of pulmonary lobes becomes a more difficult and challenging task, since the collected CT images consists of anatomical dissimilarity and imperfect fracture. On other way, constant in patients through usual lung parenchyma the fissures are frequently not absolute [2]. The automatic Segmentation of pulmonary lobes is appropriate in numerous scientific and medical applications. Consider an example of lobewise quantification is practically used for make a diagnosis and examine pathologies. Some cancer diseases diagnosis and identification is restricted because of the less information especially for long lobe. During this process lung lobe segmentation plays a major important for identification of diseases .In lung lobe segmentation methods segmentation of pulmonary becomes a very difficult and challenging issues for CT images ,since changeable reflection resolution and feature obtained through dissimilar CT scanners. Furthermore, difference in examination is numerous, and imperfect fracture is frequent, particularly in rigorous lung disease cases.

In literature several numbers of works have been proposed for lung lobe and pulmonary fissure segmentation. In [3-7] presented a segmentation methods based on lobar fissure for CT data. Intended for patients through absolute pulmonary fissures is adequate to attain lung lobe segmentation. Because in numerous cases fissures are imperfect added methods are needed to complete the lobe segmentation designed for management planning of patients through emphysema [8].

In order to solve all of the existing lung lobe segmentation methods in the literature , in this paper presents a novel lung lobe image segmentation methods which is expanded from earlier work in the literature [9] .This method is applied to publicly available datasets with 1000 datasets and referred from [10]. The work in the literature [9] is done based on the dataset with lobar airways and vasculature .It is also applied for incomplete or missing fissures. Though the result achieved from this method is also less accurate, even in the neighborhood of obviously observable fracture, and frequently necessitate manual modification. To conquer this entire problem in this work presents novel lung lobe

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segmentation methods through unambiguously segmenting noticeable fissure fragments and incorporate the original information addicted to the well-proven accessible segmentation structure. In this work, an automated novel lung lobe segmentation method is applied to computed tomography (CT) which separates the lung lobes into several categories which is discussed in earlier. In the final stage of the work cost image is calculated through mixing the information of fissures, bronchi, and pulmonary vessels. In initial stage, the lobar markers are determined by the calculation of labeled bronchial tree. Measure of medium truth degree (MMTD) is employed for automatic segmentation of lung lobe. MMTD measure the similarity between the original pixels and make use of correlation of the pixel .The experimentation results of the proposed MMTD- Lobar segmentation is compared with earlier methods and it applied for 20 CT scans through rejection or mild disease.

II. RELATED WORK

In recent work automatic lung and lobe based image segmentation methods in introduced in kuhnigk et al [9]. In this automatic lung lobe segmentation the segmentation is performed based on the watershed transformation with the intention of obtain an examination of lobar airways and vasculature addicted to description. It shows the lung lobe segmentation based on the watershed transformation achieves higher segmentation results especially for missed fissures however consequently normally imprecise next to obviously observable fissures, it is applied for 1000 datasets CT samples, though the results achieved this schema is not higher accuracy and not validated.

Some other lung lobe automatic segmentation is also proposed in [11] based on multi-atlas approach. In the initial stage of the work the CT images are divided into lungs, fissures, and bronchi, which is combined as single image and known as cost image. A high-speed listing of this result through a position of five atlases through absolute fissures give the most excellent identical atlas with the intention of is preferred designed for an all right registration in the direction of obtains the lobe segmentation result. The major issue of this schema is that it requires more time to complete the process and several numbers of scans required to complete the lobar segmentation correctly.

Ukil and Reinhardt [12] develop automatic image segmentation for pulmonary lobes which is like similar to [9]. In the initial stages of the pulmonary lobes were segmented by the use of watershed transformation. This transformation method is performed based on the distance function from the vasculature and lobe markers which is represented as bronchi tree structure. In the following step optimal surface detection is carried out for 3D image to find exact ROI for initially segmented fissures. At end of the work imperfect fissures were performed based on fast-marching method. Major issue of the work is that it 20-25% of the manual interference is occurred during pulmonary lobes segmentation.

Automatic lobe segmentation approach is developed in [13] and extended from [9] .Instead of consideration of lung fissures these methods consider the information of pulmonary fissures for the watershed segmentation. The fissure structures of lung lobes are determined based on the Hessian matrix. Automatic lobe segmentation approach is experimented and evaluated through 42 data sets, achieves 96.8% results. Current fissure is characterized in the form of 3D space with morphological processing [14]. From the results of the 3D curve and ROI, lobar is instantly computed. Automatic lobe segmentation with 3D curve is experimented and evaluated to 25 normal-dose CT scans. Segmentation of lung airways especially for CT images is demanding, because the parenchymal fracture frequently has equivalent Hounsfield Unit significance comparable in the direction of Lumen. Two pre-processing steps are functional in this schema namely, Gaussian smoothening [15] and bronchial tree [16]. Gaussian smoothening is mainly performed to reduce the noises in the input image samples. The bronchial tree is mainly applied to enhance the quality of the input image samples. The significance of bronchial tree filtering is to distinguish the voxels with the purpose of are enclosed through dense round formation. In conclusion to division the BT, region growing algorithm [17], is second-hand subsequent to apply thresholding in the direction of the enhanced image.

III. PROPOSED AUTOMATIC LOBAR SEGMENTATION ALGORITHM FOR PULMONARY LOBES FROM CHEST CT SCANS ALGORITHM

Novel lung lobe image segmentation methods which are expanded from earlier work in the literature [9]. In this automatic lung lobe segmentation the segmentation is performed based on the watershed transformation with the intention of obtain an examination of lobar airways and vasculature addicted to description which separates the lungs into lobes. In initial stage, the lobar markers are determined by the calculation of labeled bronchial tree. A Through combination of information from numerous anatomical formations is created alongside imperfect fissures. Though the result achieved from this method is also less accurate, even in the neighborhood of obviously observable fracture, and

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frequently necessitate manual modification. To conquer this entire problem in this work presents novel lung lobe segmentation methods through unambiguously segmenting noticeable fissure fragments and incorporate the original information addicted to the well-proven accessible segmentation structure. Measure of medium truth degree (MMTD) is employed for automatic segmentation of lung lobe. MMTD measure the similarity between the original pixels and make use of correlation of the pixel of spatial features. To match the exact results of the each category MMTD is measured between the pixels which repeatedly applied for lobar markers. The proposed MMTD lung lobe segmentation essentially focal point on region of interest interested in a new consequential position of regions with objects and be able to be appropriate designed for each and every one images.

In initial stage of the work the pulmonary vessels are detected based on the measuring the distance values between the pixels. Let us consider initially that there are no pulmonary vessels presented inside the boundary, distance is measured between the pulmonary vessels feature to detect exact region of the pulmonary vessels. In the direction of measure the deficiency of vessels on the lobar borders, a rude segmentation of the pulmonary vasculature is adequate. There is elevated dissimilarity among blood vessels and lung parenchyma with the purpose of permit a coarse segmentation through thresholding the information inside the lung region. The objective is to consist of as numerous vessels as potential however eliminate fissures and additional intense structures. In thersholding schema the pulmonary vessels vorig is balance through the 8-bit range [0, 255], where 255 marks voxels is presented outside the lung mask L:

$$v_{ds} = \begin{cases} max\left(0, min\left(254, \frac{v_{orig} + 1024}{4}\right)\right) & v \in L \\ 255 & otherwise \end{cases} \quad (1)$$

$$V = 130 \leq v_{ds} < 255 \quad (2)$$

After the completion of this thresholding schema , a connected constituent examination filters out formation through a amount of less than 2 ml is separated from vasculature with high density formation such as thickened component of the fissures.

In the second step of the work pulmonary fissures is segmented from lung pulmonary image through fissure segmentation is performed based on the enhancement methods which follows eigen values of the Hessian matrix . This matrix gives the probability value of fissure for each voxel presented inside the fissure ,these values are represented in the form of $|\lambda_1| \leq |\lambda_2| \leq |$ of the Hessian matrix H is determined based on the derivative-of-Gaussian approach with $\sigma = 1.0\,m$. Fissures are able to in the neighborhood be representation as a sheet wherever the eigen value of fissure is high , and remaining eigen values of the normal becomes small . So the bright eigen value of fissure is represented as $|\lambda_1| = |\lambda_2|$ = and ≪ 0. From this steps the fissure enhancement method which distingue the voxels of fissures which is described as follows: 0 ≪ | | and | | 0. parameter is introduced in this work to measure difference among fissures and vessels because vessels frequently demonstrate a better | | than the image contrast. From this point of view two main important features are extracted from image:

$$F_{strucuture} = \Theta(-\lambda_3)e^{\frac{-(\lambda_3-\alpha)^6}{\beta^6}} \quad (3)$$

$$F_{sheet} = e^{\frac{-(\lambda_3)^6}{\gamma^6}} \quad (4)$$

$F_{strucutu}$represents the potency of image formation. Since the greatness of the fissure formation differs together among patients and also inside a particular dataset, an extensive gap of intensities designed for elevated fissure probability. This is performed through the calculation of sixth power which results a round rectangular-like curvature.

In the third part of the work lobar boundaries are segmented through the formation of bronchial tree, for each lobes and this is most efficient method to detect the boundary values of lobes for each vessels. In CT images, the airway lumen is shadowy and divided beginning the parenchymal tissue through emaciated airway partition formation with the intention of materializes into brighter. The watershed transformation is proposed in recent work to obtain an examination of lobar airways and vasculature addicted to description, but it becomes difficult since the parenchymal fissures comprise comparable HU importance as the lumen, and together partial volume effect (PVE) and noise presented in the airway walls so it becomes difficult to understand . Apply the following two steps to perform lobar segmentation in BT. Gaussian smoothening is mainly performed to reduce the noises in the input image samples through predetermined kernel width (= 1.0 voxel). The bronchial tree is mainly applied to enhance the quality of the input image samples. The significance of bronchial tree filtering is to distinguish the voxels with the purpose of are enclosed through dense round formation. At end of the step the enhancement image is deduct beginning the unique

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image to obtain dark values within the bronchi.At each stage of the work the distance is measured between the normal pixel features and the segmented pixel features to differentiate the vessels, fissures and lobe boundaries. To perform this process MMTD is measured at each stages and it is represented as d_b, c. To integrate the fissure information into the distance function ROI is found and then MMTD distance measure is calculated . All the information of the distance values ($d_b, d_v,$ and the original image) is integrated into the single image is known as cost image are combined through equivalent weight to a single cost image

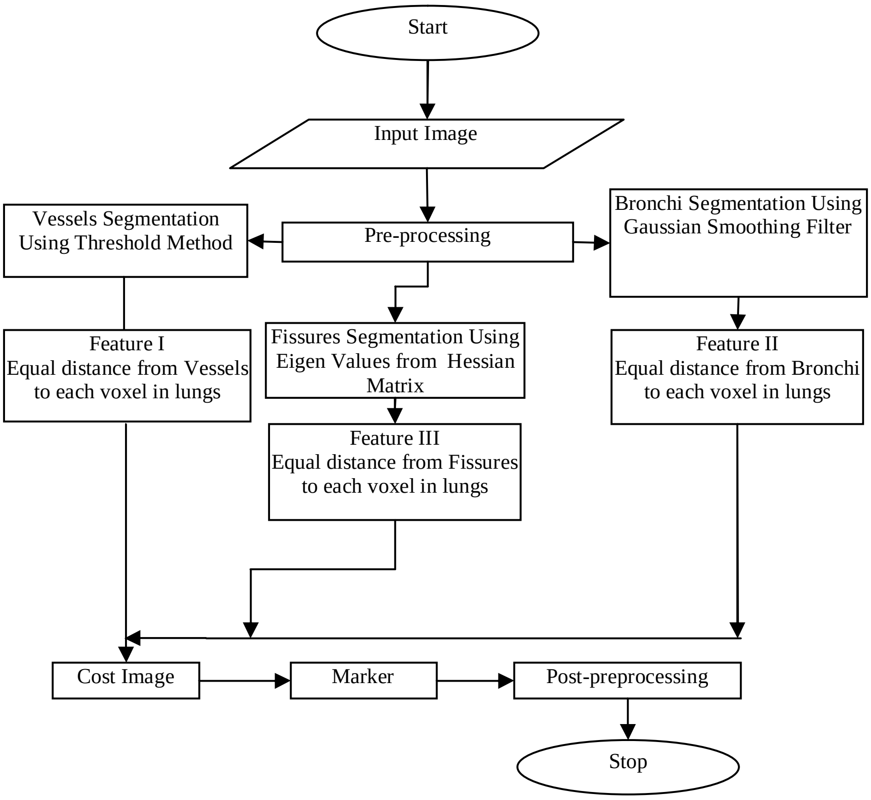

Fig.2. Flow Chart For Lungs Segmentation

Medium Similarity Measure between the pixels value of the lobe, fissure and voxel .The MMTD measure is introduced in [18-19] and it is determined between pixels $x(i$ and segmented pixels $f(i$ from ranges of $0 \sim 2$. If the two pixels may occur at the same values but occurs at the different location in the image ,then determine the similarity between the pixels $S(x(i,j), f(i,j$ transition. According to this MMTD measure is determined between pixels $x(i$ and segmented pixels $f(i$ based on the similarity is described as follows,

$$hh(f(i,j), x(i,j)) = \frac{1}{2}[h(f(i,j), x(i,j)) + h(x(i,j), f(i, \qquad (5)$$

Where (6)

$$h(f(i,j), x(i,j)) = \begin{cases} \frac{d(f(i,j), -1)}{d(x(i,j), -1)} & f(i,j) < x(i,j) \\ 1 & f(i,j) = x(i,j) \\ \frac{d(f(i,j), 256)}{d(x(i,j), 256)} & f(i,j) > x(i,j) \end{cases}$$

$d(a,$ is defined as the Euclidean distance measure between two pixels , which is determined as $d(a,b) = \|a -$ .If the value of the distance is high then the MMTD is also high. If the value of the MMTD becomes larger than , both the pixels $f(i$ and $x(i$ is also comparable. Value of Euclidean distance is less than the

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MMTD is also less. If the value of the MMTD becomes less than one, then both the pixels $f(i$ and $x(i$ is not equal.

IV. EXPERIMENTATION RESULTS

The automatic segmentation results of the existing watershed thersholding segmentation results and the proposed MMTD - watershed thersholding segmentation is determined and experimented to 42 clinical CT datasets, which consists of 16 emphysema, 3 fibrosis, and 12 tumor cases. The image resolution of each plane is measured based on the 0.4mm, 0.8 mm, and the slice width among 0.5mm - 1.5 mm. Reference segmentation results is created through a person specialist who physically describe fissures on 8-15 slices designed for every lung in each dataset. Consequently, a deformable exterior involuntarily interpolated the fissures toward each and every one in the middle of slices. Through further interface, it was probable to adjust the segmentation in anticipation of the preferred accurateness was obtained. The watershed thersholding segmentation results and proposed MMTD - watershed thersholding segmentation is experimented in MATLAB 2010a on windows 7 environment.

The automatic segmentation results of the existing watershed thersholding segmentation results and the proposed MMTD - watershed thersholding segmentation is determined and experimented to 42 clinical CT datasets, the lobewise Dice coefficient is measured between the segmented image and the reference segmented image. The Dice coefficient results of the proposed (MMTD-WTS) and existing WTS for six datasets is given in Table 1. A paired t-test is also performed between proposed (MMTD-WTS) and existing WTS for six datasets which shows the proposed methods attains $p < 0.005$. The experimentation results of the each and every stage specified is experimentally shown in Fig.3-7.

Table 1. Dice coefficients (in %) of the lobe-wise evaluation for Experiments 1

Lobe	Experiment 1	
	MMTD-WTS	WTS
LU	99.2	98.2
LL	98.36	97.9
RU	98.78	97.1
RM	93.89	92.8
RL	98.79	97.9
Average	97.804	96.8

In the table 1, MMTD - watershed thersholding segmentation and WTS.

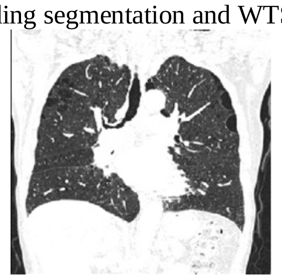

Fig. 3. Input image samples

The input samples results for lung lobe segmentation is shown is illustrated in Fig.3

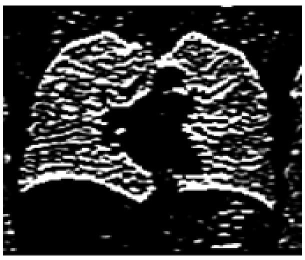

Fig. 4. Fissure segmentation

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After applying the fissure segmentation for lung lobe segmentation is shown is illustrated in Fig.4

Fig.5. Vessel segmentation

After completion of vessel segmentation for lung lobe segmentation is illustrated in Fig.5

Fig.6 . Cost image

After completion of vessel segmentation , fissure segmentation then results combined into new image is known as cost image for lung lobes images is illustrated in Fig.6

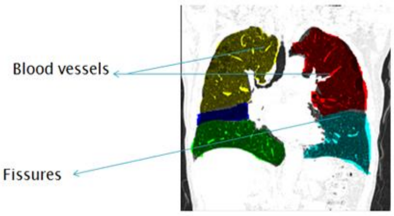

Fig.7. Lung Segmentation Results

Then final segmentation results for newly cost image is shown in Fig.7

V. Conclusion and Future Work

In this work, an automated novel lung lobe segmentation method is applied to Computed Tomography (CT) which separates the lung lobes into several categories which is discussed in earlier. In initial stage of the work the pulmonary vessels are detected based on the measuring the distance values between the pixels. In the second step of the work pulmonary fissures is segmented from lung pulmonary image through fissure segmentation is performed based on the enhancement methods which follows eigen values of the Hessian matrix. In the third part of the work lobar boundaries are segmented through the formation of bronchial tree, for each lobes and this is most efficient method to detect the boundary values of lobes for each vessels. At each stage of the work the distance is measured between the normal pixel features and the segmented pixel features to differentiate the vessels, fissures and lobe boundaries. All the information of the distance values (d_b, d_v, and the original image) is integrated into the single image is known as cost image are combined through equivalent weight to a single cost image. MMTD measure is determined between pixels $x(i$ and segmented pixels $f(i$ based on the similarity The MMTD can categorize the pixels further properly. Moreover,

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experiments result confirms that the proposed MMTD-WTS schema achieves higher lobe segmentation results than the other methods. Future work scope of the work will be extended this work to other types of therhsolding and filtering methods applied, interactive method is applied for automatic segmentation which is faster than the existing methods and achieves higher accuracy.

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