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# An Automated Computer-aided Diagnosis System for Malignant Tumor Localization from Lung CT Images for Surgical Planning

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***Abstract---*** *Locating the cancerous (malignant) tumor is the best way to treat the lung cancer. In-vivo assessment of tumor growth in lungs supports to estimate the cancer threat. This study focused to develop a computer aided detection (CAD) scheme for automatic segmentation of lung lobes and cancerous tumor region from low dose, isotropic computed tomography (CT) images, which may aid the surgical planning for lung cancer treatment. For this retrospective study, CT scan images of 18 cancerous south Indian subjects (confirmed through biopsy test) aged between 22 to 81 years were analysed. Initially, the original CT image was preprocessed and lung lobes were segmented by adaptive fissure sweep and Dual Tree Complex Wavelet Transform (DTCWT). After processing through spatial fuzzy clustering with level set approach, malignant tumor was segmented. Lastly, the segmented malignant tumor was placed over lobes to display its actual position. Two radiologists were appointed to manually segment the lobes and malignant tumor from the CT lung slices of all the 18 cancerous subjects. To validate the result, cancerous tumor in those CT slices were marked manually by the independent radiologists and taken as ground tooth image. The outcomes suggests that the developed CAD system can detect the cancerous tumor location and thereby may help the surgeons to plan for surgery.*

***Keywords---*** *Diagnosis System, CT Images, Surgical Planning.*

## I. INTRODUCTION

Lung cancer is deadly cancer in men, which develops due to the smoking habits[1]. It affects smoking population in the world. It is difficult to find the lung cancer in the initial stages (stages 1 and 2) due to absence of symptoms. However, in advantaged stages (stages 3 and 4) symptoms will appear but that stage, the cancer would have spread to near and distant organs. Hence it is very difficult to extend the life time of patients with lung cancer[2]. Surgical removal or lobectomy is the favorite choice for treatment of lung cancer in the advanced stages.

The human lungs have five lobes which are divided by lobar fissures[3]. The right lung has inferior, middle and superior lobes, which are divided by right oblique and horizontal fissures. Left obligue fissure divides the left lung into inferior and superior lobes.

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Most important radiographic imaging tool for the segmentation of lobes and cancerous nodules in the lungs is the computed tomography (CT) images[4]. In present medical practice, physicians read stacks of computed tomography for identifying the diseased lung lobes[5]. For surgeons, reading CT image is not an easy task. Because of this accuracy of identifying cancerous lobes will be less. Hence, computer-aided diagnosis (CAD) system is needed to diagnose malignant lung lobes automatically[6].

A pipelined algorithm developed by Qiao et al. utilized adaptive fissure sweep and watershed algorithm to segment lung lobes[7].

Accuracy of their work was 85% to 92.3% fissure regions localization. However, the surgeons obtained an accuracy of 80% using the same CT images. Later, they developed another algorithm by utilizing modified adaptive fissure sweep and wavelet transform[8]. The algorithm produced an accuracy of 76.7% to 94.8%. Further, they developed 3-D structure of lung lobes via software AMIRA. In our earlier study, we have developed a dual tree complex wavelet transform (DTCWT) and adaptive fissure sweep to identify lobar fissures in computed tomography images[9]. Using our algorithm we achieved accuracy of 85% to 95.2% fissure regions localization.

The automatic separation of malignant tumors is the key for the treatment of patients with lung cancer. Various research groups have developed several algorithms for the separation of malignant tumors automatically. To find nodule candidates from the segmented lung volume, the major techniques used were mathematical morphology[10,11], multiple thresholding[12,13] and clustering[14-15].

The key for surgical procedure is identification lobes and malignant tumors. Segmentation of lung lobes for cancer localization (presence of cancer in the lobe) by the extraction of lobar fissures are still challenging task for the experienced surgeons.

Further, segmentation of cancerous tumor region in isotropic CT image is very crucial in medical diagnosis to make the final decision by the experts. This study is focused to develop a frame work to segment the lobes and malignant tumors automatically from cheat CT images.

## II. MATERIALS AND METHODS

### *2.1 Data collection*

This work is aimed to locate the lung cancer along the lobes. The 18 patient's images with lung cancer collected retrospectively from the Bharat Scans, Chennai, India. Bharat scan's institutional ethical committee approved the protocol opted for this study.

The CT chest radiologists (they are not participated in observer study) were admitted by the Scan center to select the 18 patients (13 males and 5 females) with cancerous lung tumor of size ≥ 3 mm from their data base, for whom this wok was carried out.

### *2.2 Methodology*

Figure 1 shows the proposed flow diagram for lung cancer diagnosis system.

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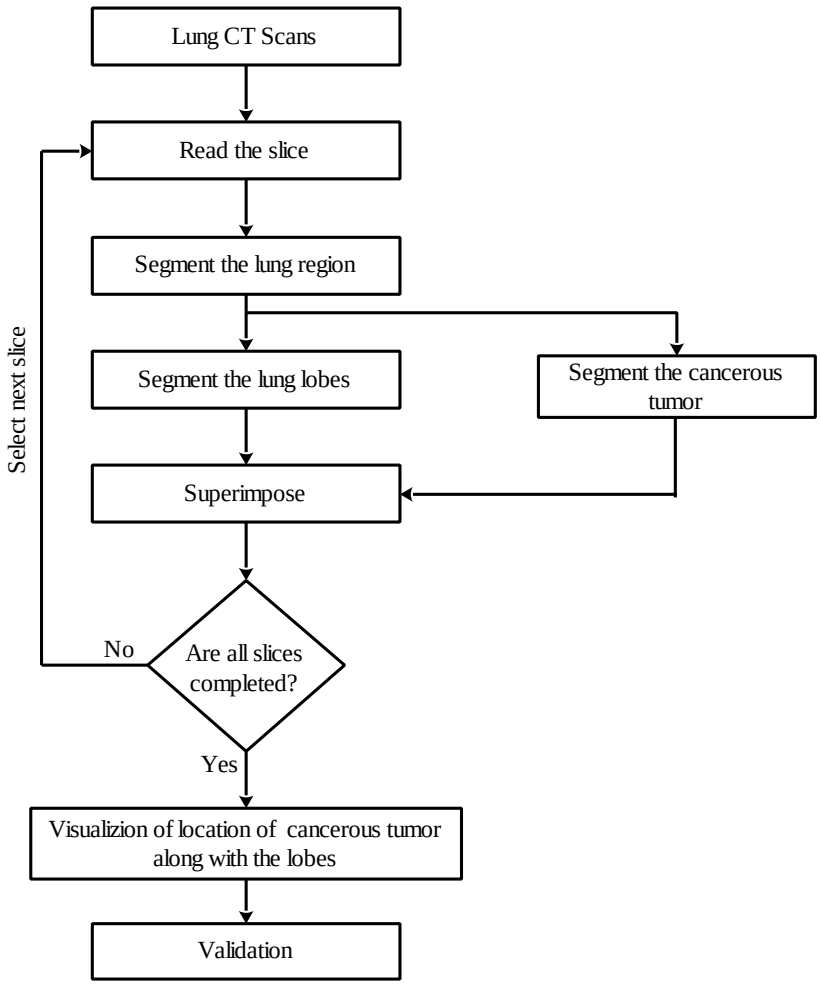


Fig. 1: Flow diagram of proposed lung cancer diagnosis system

### *2.3 Automatic segmentation of lung lobes*

#### *2.3.1 Adaptive fissure sweep*

The first step in segmenting lung lobes involves identification of fissure region in acquired computed tomography images. Before identifying fissure region, preprocessing is performed on the original isotropic CT images. Preprocessing was aimed to minimize the noises present in the CT images. The main techniques were used in this context were: mean filter, median filter, Gabor filter, enhancement filter, fast Fourier transform, Wavelet transform, smoothing filter, erosion filter, Weiner filter etc. We used Wiener filter for removal of noise. Wiener filter is an optimum filter for removing noises from CT images. Then adaptive fissure sweep method is utilized to segment the left oblique fissures and right oblique fissures.

#### *2.3.2 Dual tree complex wavelet transform (DTCWT) and connected component labelling*

To extract the fissures in the found fissure regions, Dual Tree Complex Wavelet Transform (DTCWT) is developed in this work. Application of DTCWT on original CT images results high pass filtered sub images for vertical, horizontal and diagonal directions and low pass filtered sub image. Most of lobar fissures appears

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horizontally, hence horizontal sub images are utilized for the subsequent process. Then connected component labelling is utilized to extract the lung lobes present in the computed tomography images.

### *2.4 Automatic segmentation of cancerous tumor*

In order to segment the malignant tumor, in this work, we have proposed spatial fuzzy clustering with level set algorithm.

#### *2.4.1 Spatial fuzzy clustering*

The performance of standard FCM is often impaired by noise and artifacts; hence spatial fuzzy clustering is used in this work. The spatial fuzzy clustering approach used by Chuang et al. is utilized in this work, which is given by,

$$m'_{mn} = \frac{m_{mn}^{i} s_{mn}^{j}}{\sum_{k=1}^{C} m_{kn}^{i} s_{kn}^{j}} \quad (1)$$

Where i and j are controlling parameters in the respective contribution, $\mu_{mn}$ is the fuzzy membership function and $\mu'_{mn}$ spatial-fuzzy membership function. The variable $s_{mn}$ incorporates spatial information by

$$s_{mn} = \sum_{k \in W_n} m_{nk} \quad (2)$$

Where $W_n$ is the window centered about pixel n.

$$m_{mn} = \frac{\| i_n - o_m \|^{-2/(l-1)}}{\sum_{k=1}^{C} \| i_n - o_k \|^{-2/(l-1)}} \quad (3)$$

$$o_i = \frac{\sum_{n=1}^{N} m_{mn}^{l} i_n}{\sum_{n=1}^{N} m_{mn}^{l}} \quad (4)$$

Where $i_n$ is particular image pixel, $o_m$ is centroid of cluster m.

#### *2.4.2 Fuzzy level set segmentation*

The automated image partition for medical images developed by Li et al utilized fuzzy level set algorithm. The studies shows that fuzzy clustering with level set algorithm yielded better results in segmenting the images. The spatial fuzzy clustering with level set algorithm developed in this work for segmenting the malignant tumors automatically. For level set algorithm, the parameter configuration is automated by spatial fuzzy clustering approach. Thus, the malignant tumors are automatically segmented by employing fuzzy clustering with spatial restrictions along with level set approach.

## III. RESULTS AND DISCUSSION

First, the CT lung image is preprocessed by Wiener filter, then adaptive fissure sweep is performed to segment the lung lobes (which makes use of fissures in the lungs). Second, the spatial clustering with level set is performed to segment the malignant tumor. Segmented malignant tumor is placed over lung lobes to display its actual location for carrying out the surgical procedure. These steps are summarized in Fig. 2.

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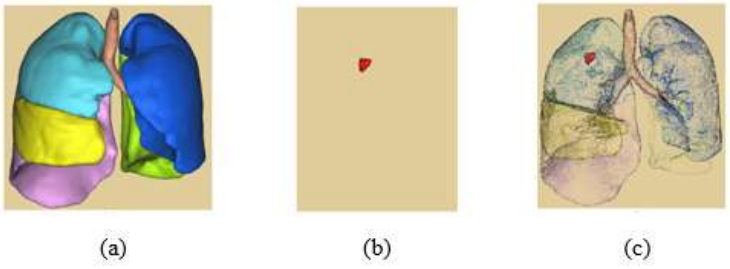


a) Segmented lung lobes

b) Segmented malignant tumor from the lung lobes

c) Segmented cancerous tumor

Fig. 2: The steps involved in lung lobe and cancerous tumor segmentation

The lung lobes were segmented by utilizing adaptive fissure sweep for a cancerous patient is given in Fig. 2 (a). Segmented lobes are displayed with different colors. The lung lobe with cyan is segmented right superior lobe. The middle lobe is shown with yellow color. The lung lobe with magenta color shows the segmented inferior right lobe. The blue color shows the segmented superior left lung. The green color is the segmented left inferior lobe. Thus, the adaptive fissure sweep performs the lung lobes segmentation. After dissection of lung lobes, malignant tumor was segmented by spatial fuzzy clustering with level set algorithm. Fig. 2 (b) presents the segmented malignant tumor from lung lobes. Segmented malignant tumor is superimposed with the lung lobes to show its actual location. The Fig. 2 (c) shows the superimposed cancerous tumor along the lung lobes. From Fig. 2 (c) it is evident that the cancerous tumor is located on the superior right lobe. The same procedure is carried on 18 patients' images and their locations are summarized below in table 1.

Table 1: Locations of cancerous tumor with lung lobes (n=18)

| # Patient | Cancerous tumor location |
|---|---|
| #1 | Middle lobe |
| #2 | Right superior lobe |
| #3 | Middle lobe |
| #4 | Left superior lobe |
| #5 | Middle lobe |
| #6 | Left inferior lobe |
| #7 | Middle lobe |
| #8 | Middle lobe |
| #9 | Middle lobe |
| #10 | Right inferior lobe |
| #11 | Left inferior lobe |
| #12 | Middle lobe |
| #13 | Left superior lobe |
| #14 | Middle lobe |
| #15 | Left inferior lobe |
| #16 | Right inferior lobe |
| #17 | Right superior lobe |
| #18 | Middle lobe |

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## IV. CONCLUSION

Leading cause for cancerous death in men are lung cancer and can be controlled with earlier detection and treatment. Location of the cancerous tumor is vital for the surgeons before planning surgical procedure. In this paper, the lung lobes were segmented by adaptive fissure sweep, DTCWT and connected component labelling. The cancerous tumor from the lung lobes was segmented by level set algorithm with spatial fuzzy clustering. The obtained outcomes shown that the proposed work could automatically segment lung lobes and cancerous tumor from the CT images.

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