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Image Processing Technique for Lung Lobes Segmentation

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Background

A novel algorithm for segmenting diseased lung lobes using a hybrid 2-D/ 3-D approach has been developed at the University of Calgary's Schulich School of Engineering. This approach primarily works by modeling complete lung fissure surfaces from partial fissures observed in individual computed tomography (CT) images. Compared to current state-of-the-art algorithms, this algorithm deals with multiple lung diseases, produces 10 % higher percentile accuracy and yields comparable RMS errors as well.

Automatic identification of fissure surfaces is generally difficult due to the lung fissures' shape variability and appearance, along with the low contrast and high noise found in CT images. Furthermore, current segmentation methods such as deformable models and level sets are rendered unsuitable for fissure identification due to CT image noise, incomplete fissures and the growing need for manual initialization. Unlike these methods, the technique proposed here is efficient in terms of generating complete segmentation of diseased lung lobes where fissures are usually disrupted, deformed and deficient.

Algorithm	Automation	Evaluated on Multiple Diseases	Segmentation in 3-D
	2-D Fissure Approach		
Extraction Algorithm - Thin-section CT	YES	NO	NO
Atlas-driven	NO	YES	NO
Ridge map and curve-growing process	NO	NO	NO
	3-D Surface Approach		
Anatomy-guided 3-D water-shed transform	NO	NO	YES
Sequential Region-Splitting	YES	NO	YES
Extraction Algorithm – Low-dose multislice CT	YES	NO	YES
Implicit Surface Fitting	YES	NO	YES
2-D/ 3-D Hybrid Approach	**YES**	**YES**	**YES**

Table 1 State-of-the-art Algorithms for segmenting all lung lobes

The hybrid 2-D/3-D approach that this technology makes use of, works by initially discovering fissures in 2-D

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CT images using a texture analysis method and then a surface fitting technique based on ridge regression is used to model actual fissure surfaces in 3-D. The algorithm used here employs a pipeline process to segment the lobes which takes places in four stages including preprocessing, 2-D oblique fissure recognition, 2-D horizontal fissure recognition and lastly 3-D lung lobe segmentation. In this manner, it forms an effective and competent diagnostic/ treatment system using isotropic CT images.

Area of Application

- Computed tomography for lung imaging

Competitive Advantages

- This technique allows detection of fissure that are often disrupted and deformed by lesions like in cancerous lungs
- It produces complete fissure surfaces allowing the lung lobes to be visualized in three dimensions
- Another advantage of this approach is the ability to extend incomplete fissures to the boundaries of the lungs using the 3-D fissure surfaces
- It allows control over the smoothness of the fissure surface by varying the smoothing coefficient which ensures smooth connectivity between fissures in adjacent CT images

Stage of Development

- The algorithm was evaluated by the researchers using lungs with a variety of different disease conditions such as emphysema, small cell lung cancer (SCLC), large cell lung cancer (LCLC) and bronchiectasis and it was found that the algorithm successfully produced complete segmentations of these diseased lung lobes.

Publications:

- Q. Wei, Y. Hu, "A Hybrid Approach to Segmentation of Diseased Lung Lobes," *IEEE Journal of Biomedical and Health Informatics (IEEE Press)*, vol. 18, no. 5, pp. 1696-1706, 2014
- Q. Wei, Y. Hu, J. H. MacGregor, G. Gelfand, "Automatic recognition of major fissures in human lungs," *International Journal of Computer Assisted Radiology and Surgery (Springer), vol. 7, no. 1, pp. 111-123,* 2012