Vessel Segmentation in Lungs

Algorithm description

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The main steps of the algorithm:

1. Data normalization
   Input data is normalized to the common range of intensities equal [0,1]. The normalization is performed in accordance with the following equation:

   $$I_2 = \frac{I_1 - I_{\min}}{I_{\max} - I_{\min}} \tag{1}$$

   where: I_1 - voxel intensity in the input image; I_2 - voxel intensity in the output image; I_{max} - maximum voxel intensity in the CT volume; I_{min} - minimum voxel intensity in the CT volume.

2. Intensity distribution analysis in the lungs
   Seeds detection and region expansion are controlled by thresholds determined from intensity distribution in the lungs. Intensity histogram in this region is usually bimodal and contains two peaks: the *background peak* at intensity T_1 and the *object peak* at intensity T_2 (see Fig.1). A threshold for region growing is determined as follows:

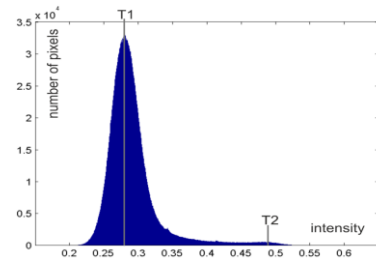 $$T = 0.5*(T_1 + T_2) \tag{2}$$

Fig.1. Intensity distribution in the lungs.

3. Seed regions detection
   The growing starts from seed regions i.e. sets of object pixels of the intensity higher than T_2 and area above 50 pixels. These regions correspond with the main pulmonary vessels.

4. Vessels & airways segmentation using 3D seeded region growing
   In the input CT scans vessels and airways are characterized by a very similar intensities. Therefore, the proposed method firstly extracts both these anatomical structures and then removes airways. Airways and vessels are extracted from lungs via region growing performed with regard to 26-connectivity and threshold T (see Eq. 2). Specifically, method starts from seed regions (determined as described in Sect. 3) and includes into the region all 26-connected pixels of the intensity above T.

5. Airway tree segmentation and airways removal
   Airway tree is extracted from lungs using the method described in [1]. Next, pulmonary vessels are determined by removing an airway tree from the results of region growing. Before the removal, in order to extend airway lumen onto the airway walls, dilation with big structuring element is performed on the airway tree. Next the overlapping regions are removed in order to obtain vessels.

Limitations of the algorithm:

- leakages at the ending of vessels may appear
- airways may not be completely removed

Is the algorithm specifically designed to segment only certain types of scans?:

- no

Is your algorithm intended for segmenting vessel in pathological lungs?

- yes

Was algorithm optimized to work for scans with thick or thin slices:

- no

Are other technical scan parameters expected to influence segmentation performance?

- no

Was the algorithm trained with example data?

- no

What is the average runtime of your algorithm, and on which system is this runtime achieved?

- less than 5 minutes (Intel Core i7-960 3,2GHz, 24 GB RAM)

Is your algorithm automatic or semi-automatic? If user input is used, how much is needed and in what way?

- automatic

Bibliography:

[1] Fabijańska A.: *Two-pass region growing algorithm for segmenting airway tree from MDCT chest scans*, Computerized Medical Imaging and Graphics, vol. 33, pp. 537-546, 2009