Segmentation of CT Lung Scans Using Image Processing Techniques

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The Problem

- Lung cancer remains one of the leading causes of death
- Computed tomography (CT) scans are very useful for lung cancer detection
- Manually analyzing these scans is difficult
- Computer-aided diagnosis systems can help in efficient early detection

The Goal

From a CT chest scan:

1. Identify the two lungs 

2. Separate the lungs into the five lobes 

CT Scan (the Input Data)

- 3 Dimensional image in MetaImage format
- Signed 16-bit gray scale in Hounsfield units
- Three datasets
  - LOLA11 (55 scans)
  - LUNA16 (100 scans)
  - Tianchi (40 scans)
- 512x512 slices, usually 200-700 slices
- Anisotropic

Toolkit

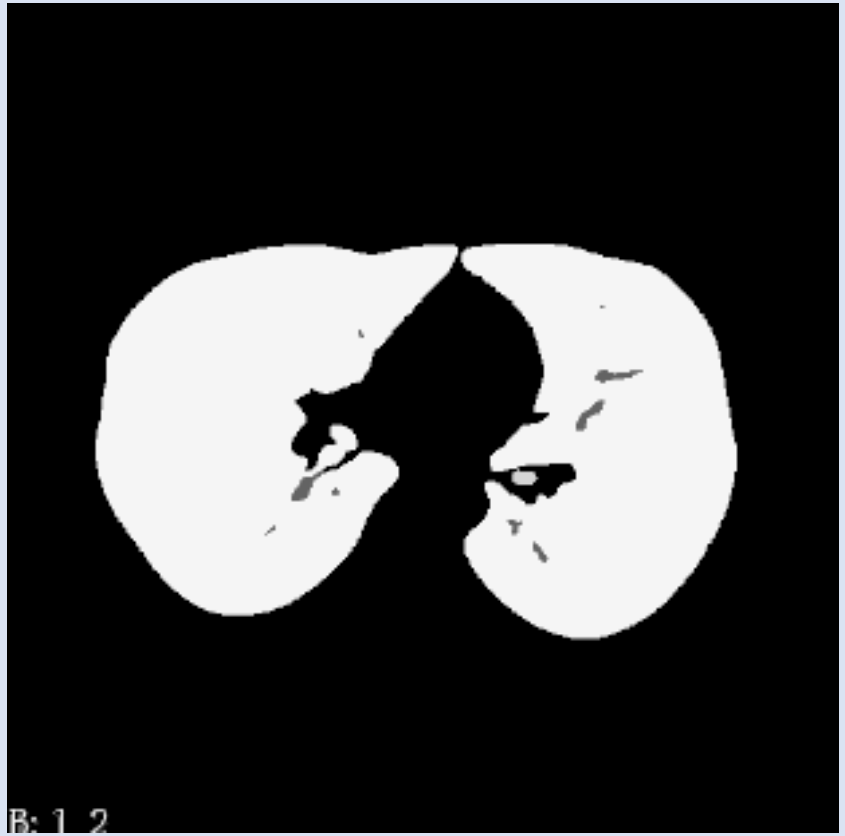
- C++
- Insight Toolkit (ITK)
  - Support for MetaImage format
  - Full support for 3D image data
  - Designed for working with medical images
- Python for rapid prototyping and testing

Lung Segmentation Approach

1. Thresholding to remove background and separate lungs from surrounding body mass
2. Separate the two lung volumes
3. Filtering to smooth the lung boundary and fill small internal holes

Thresholding Step

1. Threshold out background at -3024
2. Find adaptive threshold to identify lungs and body mass
3. Use connected component analysis to identify lungs



Separating the Left and Right Lung

1. Lungs are often very close together at a few places
2. Use dynamic programming to find a max cost path from bottom to top of each axial slice
3. If lungs are still connected in 3D, use erosion to remove connecting tissue

Final Smoothing Step

- Use dilation and erosion to smooth boundary and fill holes

Evaluation

- Manual checking of axial and coronal middle slices for LOLA11 and Tianchi scans
  - All scans were segmented correctly
- Quantiative comparison with reference segmentation for LUNA16 scans

LUNA16 Scan Results

	Overlap	Specificity	Sensitivity
Mean	0.95	0.99	0.96
Min	0.67	0.91	0.80
Max	0.98	1.00	0.98
Std Dev	0.04	0.01	0.02

- Good overall performance
- Preference for false positives over false negatives
- A few lung masks had significant internal holes
- False positive voxels form small ring around reference boundary

Attempted Lobe Segmentation Method

1. Identify sheet-like fissures using Eigen values of Hessian matrix
2. Segment blood vessels and airways and construct distance maps
3. Combine image data, fissure measure, and distance maps into a cost image
4. Use a watershed algorithm to segment a lung into the lobes

Problem

5. Could not get watershed algorithm to successfully segment lobes

Conclusions

- Lung segmentation using image processing techniques can be successful
- Determining the correct set of processes and parameters is non-trivial
- The parameters may depend on a particular dataset
- Lobe segmentation is significantly more difficult than lung segmentation
- Supposition: Deep learning may be a better approach

Questions