Pulmonary Vessel Segmentation Notes

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1 Lung Extraction Pipeline

- Threshold the CT image at -2000 to get a *cylinder* mask. The -2000 value may change across patients?

```
fslmaths /scratch/datasets/PE/PE000919.nii.gz -add 2000 -thr 0 -bin
PE919/round_mask.nii.gz
```

- First run GMM with 3 components: lung, tissue, and bones. Initial mean set to -800, 0, 1000, and initial standard deviation of GMM set to 100 for all components. In some cases, we need to run GMM with 2 components.

```
gmm --input RV01.nii.gz --seg seg.nii.gz --mask round_mask.nii.gz --ncomp 3
--mean -800 0 100 --sigma 100 100 100 --prop 0.33 0.33 0.33 --maxit 30
```

- Convert the GMM label map into a component map, so the non-connected regions with same GMM labels are assigned different component labels.

```
sitkfuncs.extract_comp('RV01/gmm_seg.nii.gz', 'RV01/cc.nii.gz')
```

- Use ITK-SNAP to check the label corresponding to the left and right lung. If left and right lungs are connected, identify only one label. Otherwise, identify both labels.

- Extract the lung component and output a binary volume.

```
sitkfuncs.extract_lung('RV01/cc.nii.gz', [1], 'RV01/lung.nii.gz', 10)
```

- Optionally, fill hole in the lung mask with the fillhole filter. ITK fillhole filter has a bug, that it only fill holes in a axial slides. That is, the filter applies only on 2D slide, instead of on 3D volume. The below command call ITK filter, so it does the same thing.

```
fillhole_filter -i lung.nii.gz -o lung.nii.gz
```

2   Vessel Extraction

- Manually define seed regions.

- Estimate the density and get a density map, which will be used as the speed map of fast marching method.

```
est_density -i RV01.nii.gz -e seeds.nii.gz -m lung.nii.gz
-o density.nii.gz
```

  The standard deviation parameter of the density estimation routine controls how much belief the user should give to the seed region. With a small deviation, only the voxels with intensity close to the mean intensity of the seed regions will have larger density value. With a larger standard deviation, the voxel have non-zero density value even its intensity is quite different from the mean intensity. Therefore, the standard deviation parameter can be seen as a regularization. A larger value will make the histogram of the density map more flat, and make Vessel and non-vessel voxels density more similar. accordingly, fast marching have more chance to propagate to non-vessel regions.

- Run the fast marching method:

```
fmm_upwind -p density.nii.gz -e seeds.nii.gz -m lung.nii.gz -t 500
-o fmm_out.nii.gz
```

- Inverse the value of the *time of visit* map to get a heat map, where larger values represent vessels.

```
inverse_distmap -i fmm_out.nii.gz -m lung.nii.gz
-o vessel.nii.gz -x 500
```