Assignment: Segment Lungs from 3D Chest Scan

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Introduction:

Lung CT segmentation constitutes a critical procedure for any clinical-decision-supporting system aimed to improve the early diagnosis and treatment of lung diseases such as lung cancer, chronic obstructive pulmonary disease (COPD), etc. Abnormal lungs mainly include lung parenchyma, lung lesions presenting various appearances. Segmentation of the lung can help locate and analyse the neighboring lesions.[1]

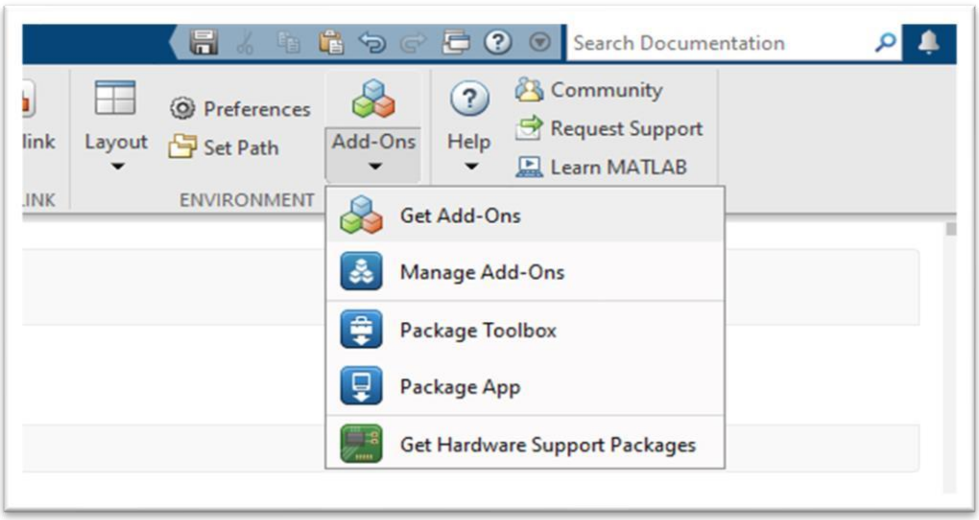
Pre-assignment task:

You may require the following MATLAB® built-in functions for this experiment and inspect their documentation–

im2single( ), squeeze( ), strel( ), activecontour( ), regionprops3( )

Install 3-D Chest Scan Using Add-On Explorer

1. Select **Get Add-ons** from the **Add-ons** drop-down menu on the MATLAB® desktop. The **Add-on Explorer** opens.



2. In the Add-On Explorer, search for the data package **Image Processing Toolbox Image Data**.

3. Click the data package in the search results. On the data package page, click **Install**.

Load Data and View

1. **Load** the human chest CT scan data into the workspace.

```
load chestVolume
whos
```

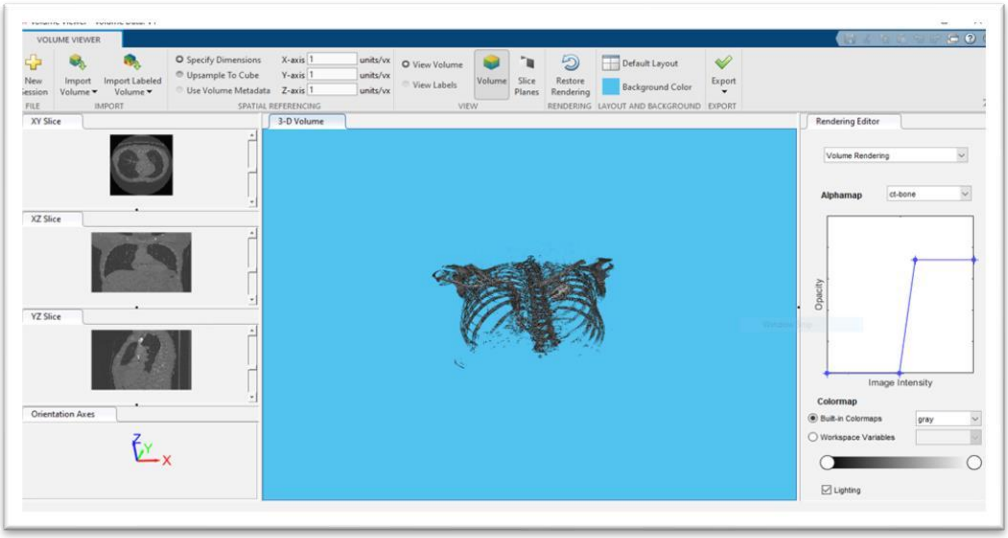
```
  Name        Size                   Bytes  Class    Attributes

  V         512x512x318          166723584  int16
```

2. **Convert** the CT scan data from int16 to single to normalize the values to the range [0,1].

```
V = im2single(V);
```

3. View the chest scans using the **Volume Viewer app**. Set **Alphamap** to ct-bone.

```
volumeViewer(V);
```



Segment the Lungs

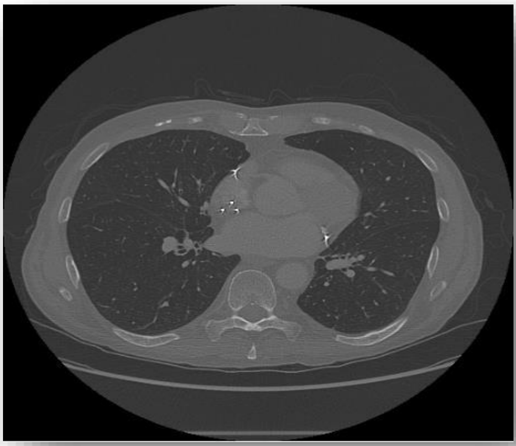
Segment the lungs in the CT scan data using the active contour technique. Active contour is a type of segmentation technique which can be defined as use of energy forces and constraints for segregation of the pixels of interest from the image for further processing and analysis. Active contour described as active model for the process of segmentation.

Image Segmenter app:

Use the Image Segmenter app to create seed mask by segmenting orthogonal 2-D slices in the XY plane.

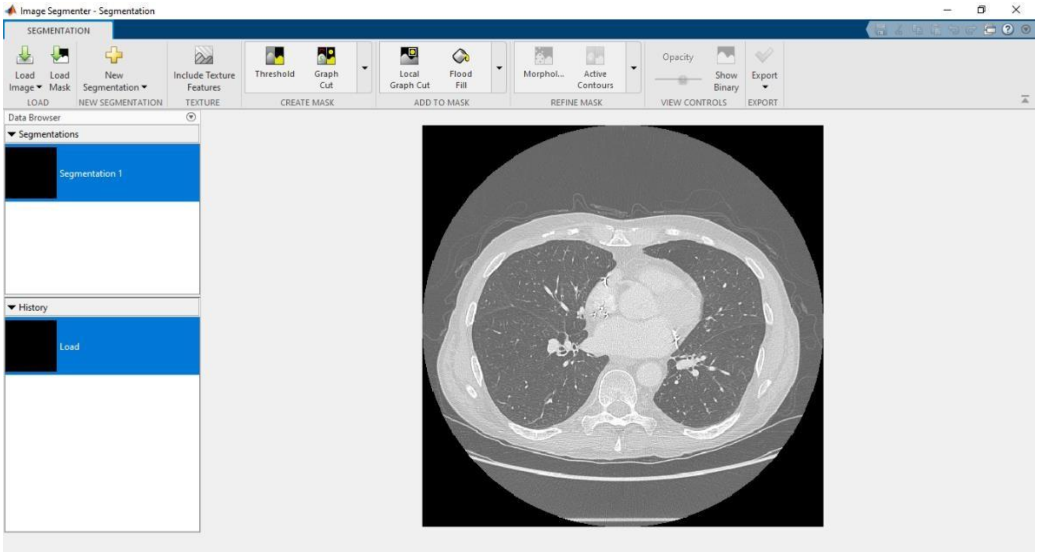
1. **Extract** the centre slice XY dimensions.

```
XY = V(:,:,160);
imshow(XY,[],'Border','tight')
```

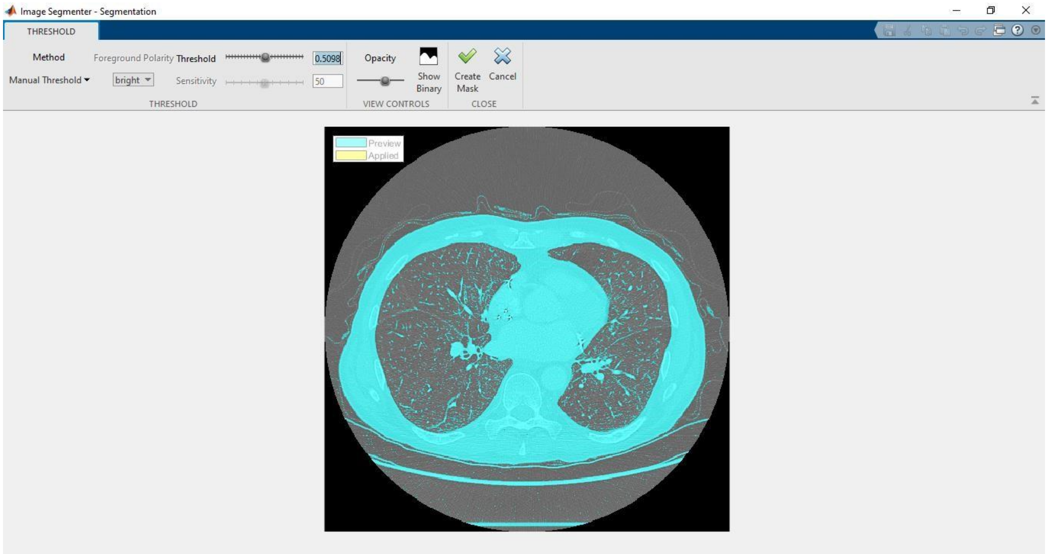


2. Perform the segmentation in the Image Segmenter app. Open the app from the MATLAB Apps toolstrip or use the **imageSegmenter** command.

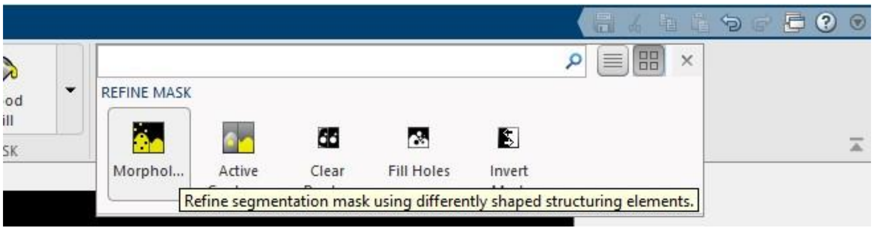
```
imageSegmenter(YZ)
```



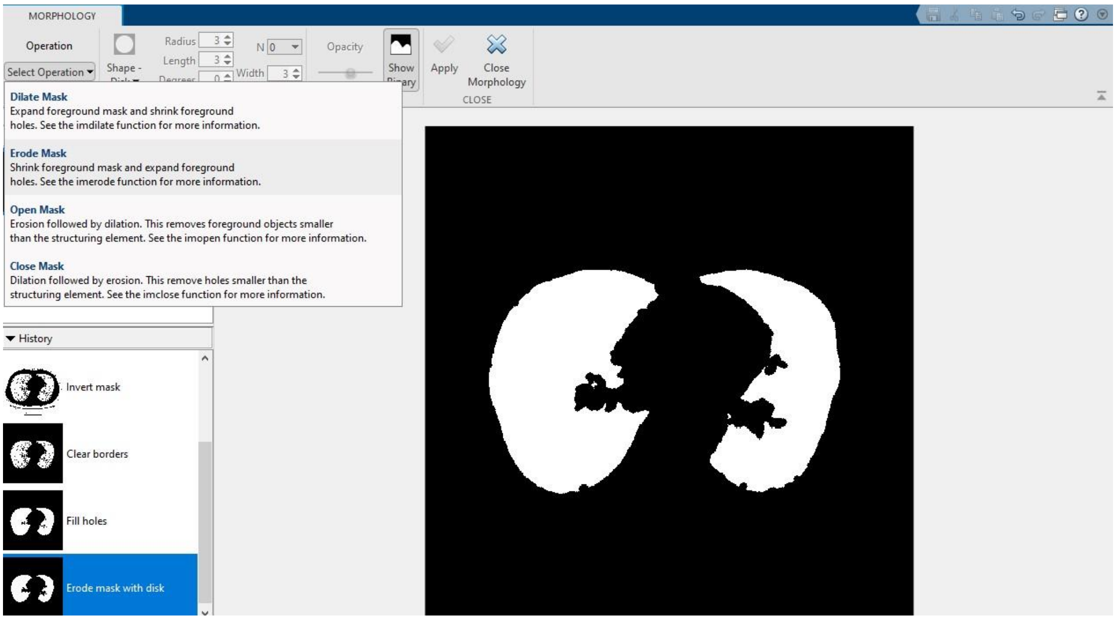
3. Click **Threshold** to open the lung slice in the **Threshold** tab. On the Threshold tab, select the **Manual Threshold** option and move the Threshold slider to specify a threshold value to 0.5098 that achieves a good segmentation of the lungs. Click **Create Mask** to accept the thresholding and return the Segmentation tab.



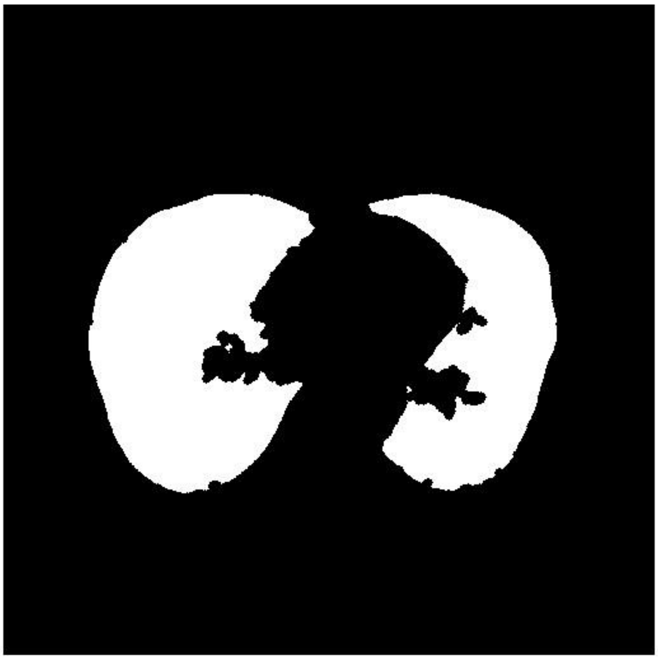
4. Clean up the mask using options on the **Refine Mask** menu. Click **Invert Mask --> Clear Borders--> Fill Holes--> Morphology**



5. On the **Morphology tab**, select the **Erode Mask** operation.



6. After performing these steps, select **Show Binary** and save the mask image to the workspace.

	
Binary Image	**Masked ImageXY**

Task 1:

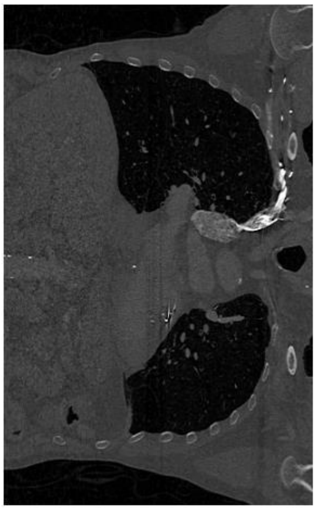
Use code to create same seed mask for the orthogonal 2-D slice in the XY plane

Manual Segmentation:

Use code to create seed mask by segmenting orthogonal 2-D slices in the XZ plane **1.**

Extract the centre slice XZ dimensions.

```
XZ = squeeze(V(256,:,:));
imshow(XZ,[],'Border','tight')
```



2. **Binarize** the slice using **imbinarize()** function. imbinarize uses Otsu's method, which chooses the threshold value to minimize the intraclass variance of the thresholded black and white pixels. (Global Threshold)

```
BW = imbinarize(XZ);
imshow(BW,[])
```

3. **Complement** the binarize image using **imcomplement()** function so that the lungs are in the foreground (**Invert Mask**)

```
BW = imcomplement(BW);
imshow(BW,[])
```

4. Suppress the light structures connected to border using **imclearborder()** function to remove other segmented elements besides the lungs (**Clear Borders**)

```
BW = imclearborder(BW);
imshow(BW,[])
```

5. Fill image holes using **imfill()** function (**Fill Holes**)

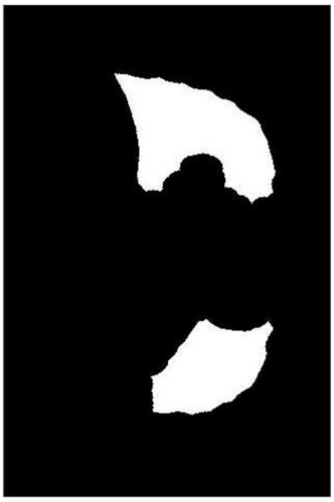
```
BW = imfill(BW,'holes');
imshow(BW,[])
```

6. You can see there are several unwanted regions, implement morphological operation(**Morphology** option) using a function called **imerode**(), which is equivalent to erosion to smooth the edges of the lung segmentation.

```
radius = 13;
decomposition = 0;
se = strel('disk',radius,decomposition);
```

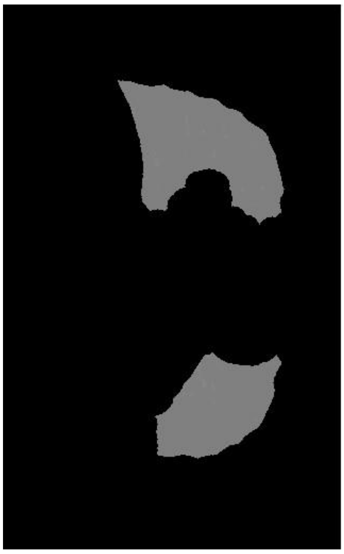
A strel object represents a flat morphological *structuring element*, which is an essential part of morphological dilation and erosion operations.

```
BW = imerode(BW, se);
imshow(BW)
```



7. Generate mask of the image.

```
maskedImageXZ = XZ;
maskedImageXZ(~BW) = 0;
imshow(maskedImageXZ)
```



Task 2:

Use Image Segmenter app to create same seed mask for the orthogonal 2-D slice in the XZ plane

Create Seed Mask and Segment Lungs Using active contour

Insert two segmentations into a 3-D mask.

1. Create a logical 3-D volume the same size as the input volume

```
mask = false(size(V));
```

2. Insert mask_XY and mask_XZ at the appropriate spatial locations

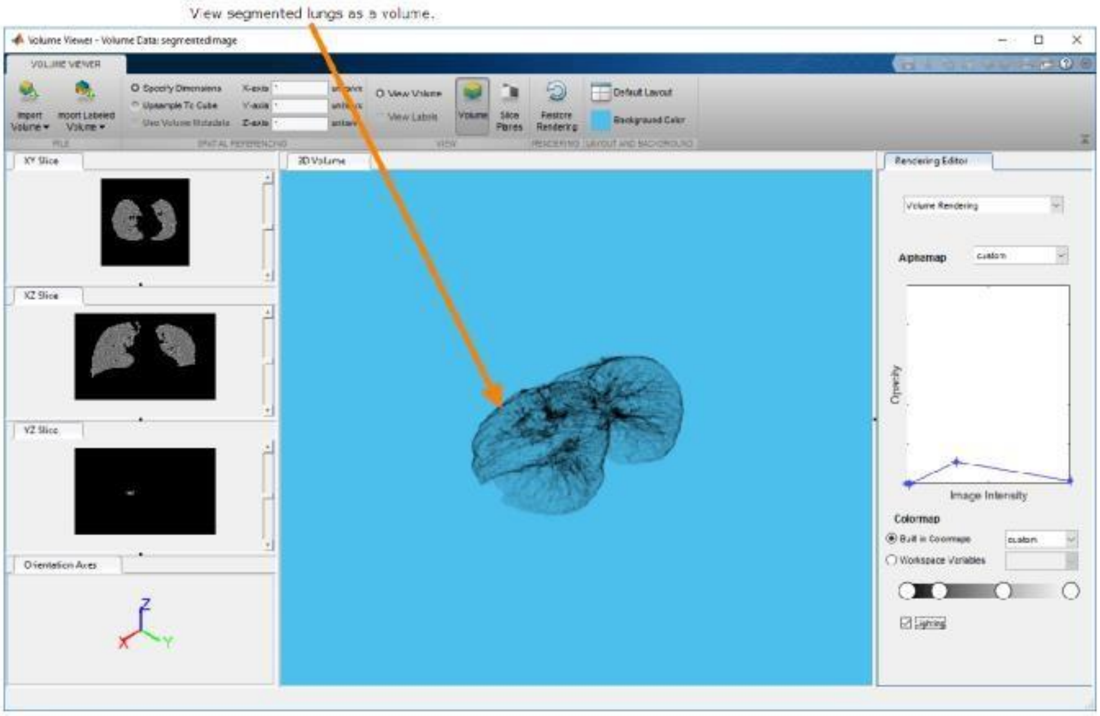
```
mask(:,:,160) = maskedImageXY;
mask(256,:,:) = mask(256,:,:)|reshape(maskedImageXZ,[1,512,318]);
```

3. Use **histeq()** to spread voxel values over the available range

```
V = histeq(V);
```

4. Using this 3-D seed mask, segment the lungs in the 3-D volume using the active contour method.

```
BW = activecontour(V,mask,100,'Chan-Vese');
segmentedImage = V.*single(BW);
```



Compute the Volume of the Segmented Lungs

1. Measure volume of 3-D volumetric CT image regions. Use the **regionprops3()** function with the 'volume' properties

```
volLungsPixels = regionprops3(logical(BW),'volume');
```

Variables - volLungsPixels

volLungsPixels

12x1 table

	1 Volume	2	3
1	4599919		
2	3329483		
3	1		
4	1		
5	2		
6	1		
7	2		
8	1		
9	2		
10	1		
11	1		
12	4		

2. Specify the spacing of the voxels in the *x*, *y*, and *z* dimensions and calculate one voxel volume.

```
spacingx = 0.76;
spacingy = 0.76;
spacingz = 1.26*1e-6;
unitvol = spacingx*spacingy*spacingz;
```

3. Calculate the volume of the lungs.

```
volLungs1 = volLungsPixels.Volume(1)*unitvol;
volLungs2 = volLungsPixels.Volume(2)*unitvol;
volLungsLiters = volLungs1 + volLungs2
```

Check your volume value with (5.7708L)

Task 3:

Use Image Segmenter app to create seed mask for the orthogonal 350th 2-D slice in the YZ plane Hints: Use flood-fill

References:

1. Xu, M., Qi, S., Yue, Y., Teng, Y., Xu, L., Yao, Y., & Qian, W. (2019). Segmentation of lung parenchyma in CT images using CNN trained with the clustering algorithm generated dataset. *Biomedical engineering online*, *18*(1), 1-21.