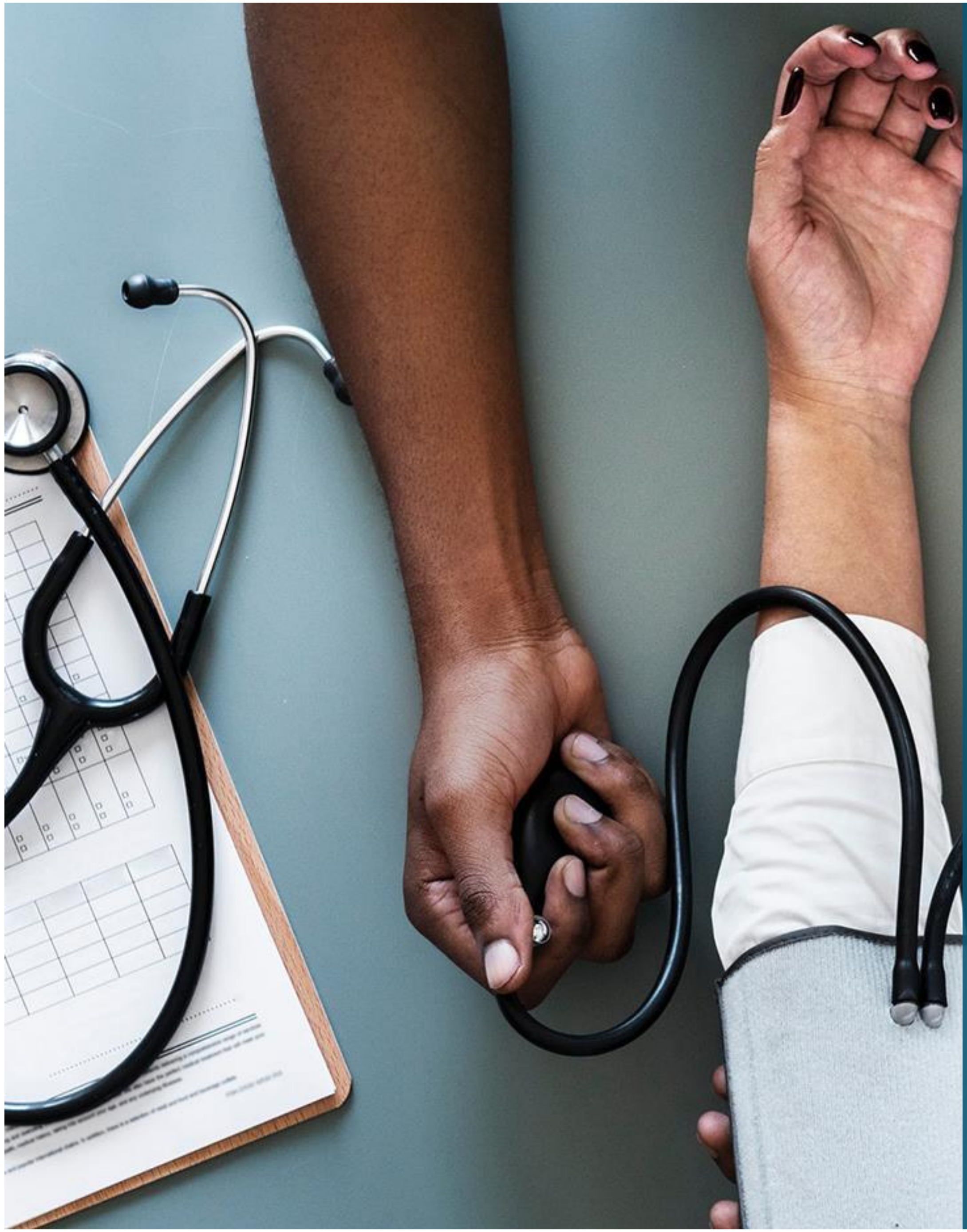

FIT3081

Image Processing

Project – Assignment 1

LUNG CANCER DETECTION USING CT SCAN IMAGE PROCESSING

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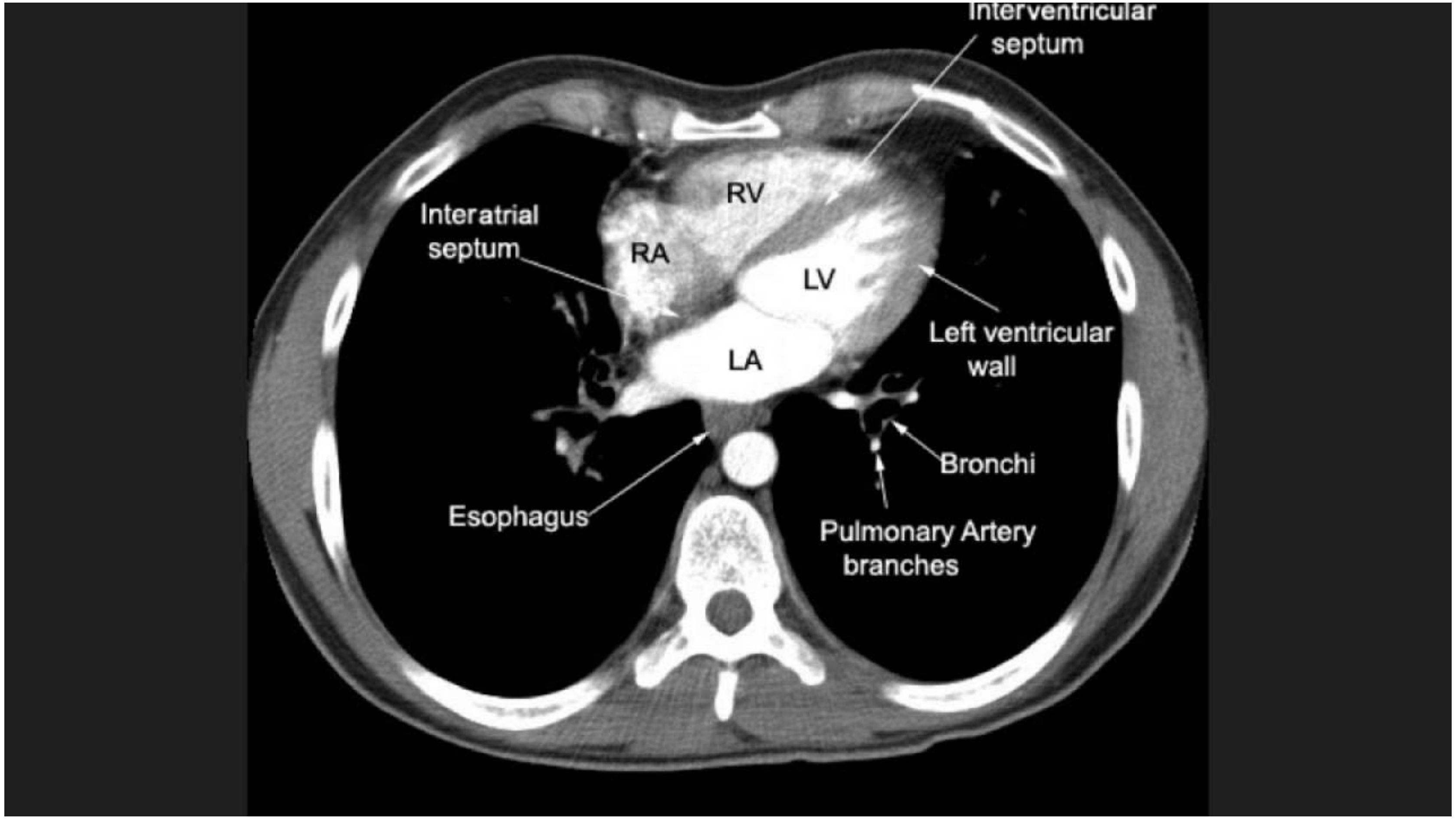
INTRODUCTION

- Lung cancer is one of the deadliest cancers
- More people die of lung cancer than other cancers
- Early detection saves life

INTRODUCTION - CHEST CT SCAN



MOTIVATION

- Comparison with other imaging techniques:
  - MRI = low availability and high cost
  - X-ray = less sensitive and gives a lower contrast

- CT scans could be improved by image processing techniques to reduce false positives and to differentiate benign and malignant tumors.

Traditional X-ray

CT Scans showing internal body

AIMS AND OBJECTIVES

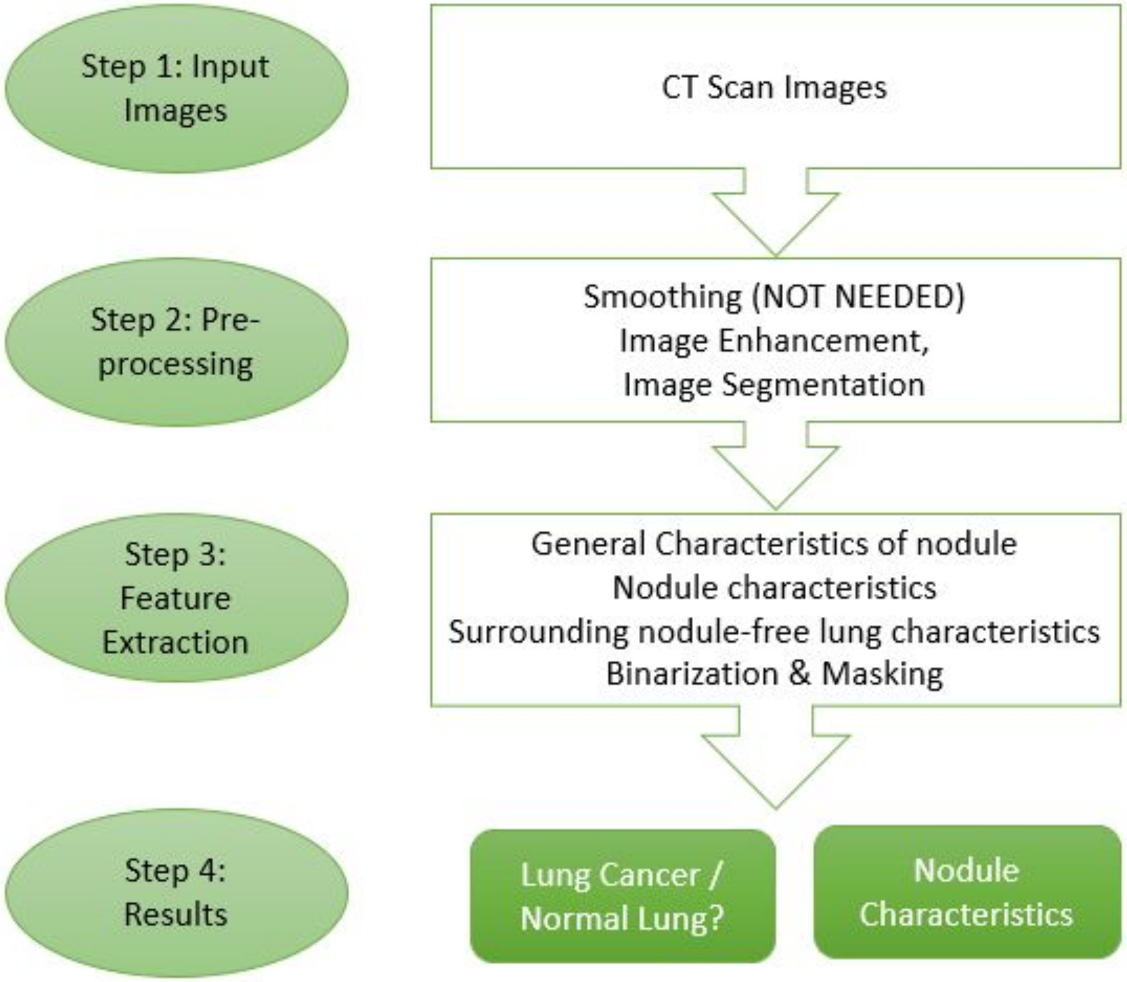
- To design and develop a system that can correctly classify images to normal/lung cancer patients by using MATLAB.

- To do a thorough literature review, analyse and compare different algorithms we explore in class and find out which techniques are the most suitable.

- To point out overall limitation, drawbacks for future improvements.

- To collect a proper dataset for our experiments

METHODOLOGY



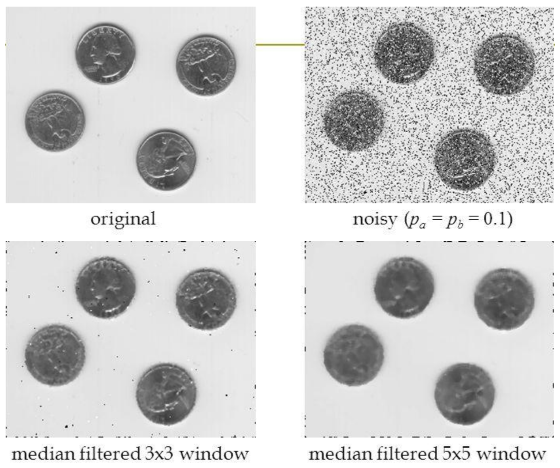
1 ST STEP: IMAGE ACQUISITION

- Cancer Imaging Archive(https://www.cancerimagingarchive.net/) provide several different datasets:
- The RIDER Lung CT collection
- The Lung Image Database Consortium image collection (LIDC-IDRI)
- Sample images:

2^{ND} STEP: PRE-PROCESSING – SMOOTHING (NOT NEEDED)

Function	MATLAB Code
To convert image into grayscale	I = rgb2gray(image;
Median filter to remove salt and pepper noise	K = medfilt2(image);
Gaussian filter to blur image and remove noises	Iblur = imgaussfilt(image, 2);

Median Filters



From MATLAB sample images

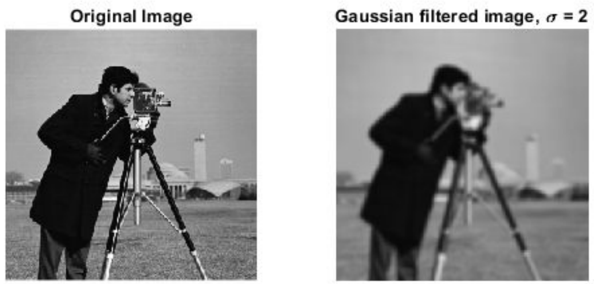



Figure 4
File Edit View Insert Tools Desktop Window Help
Original Image

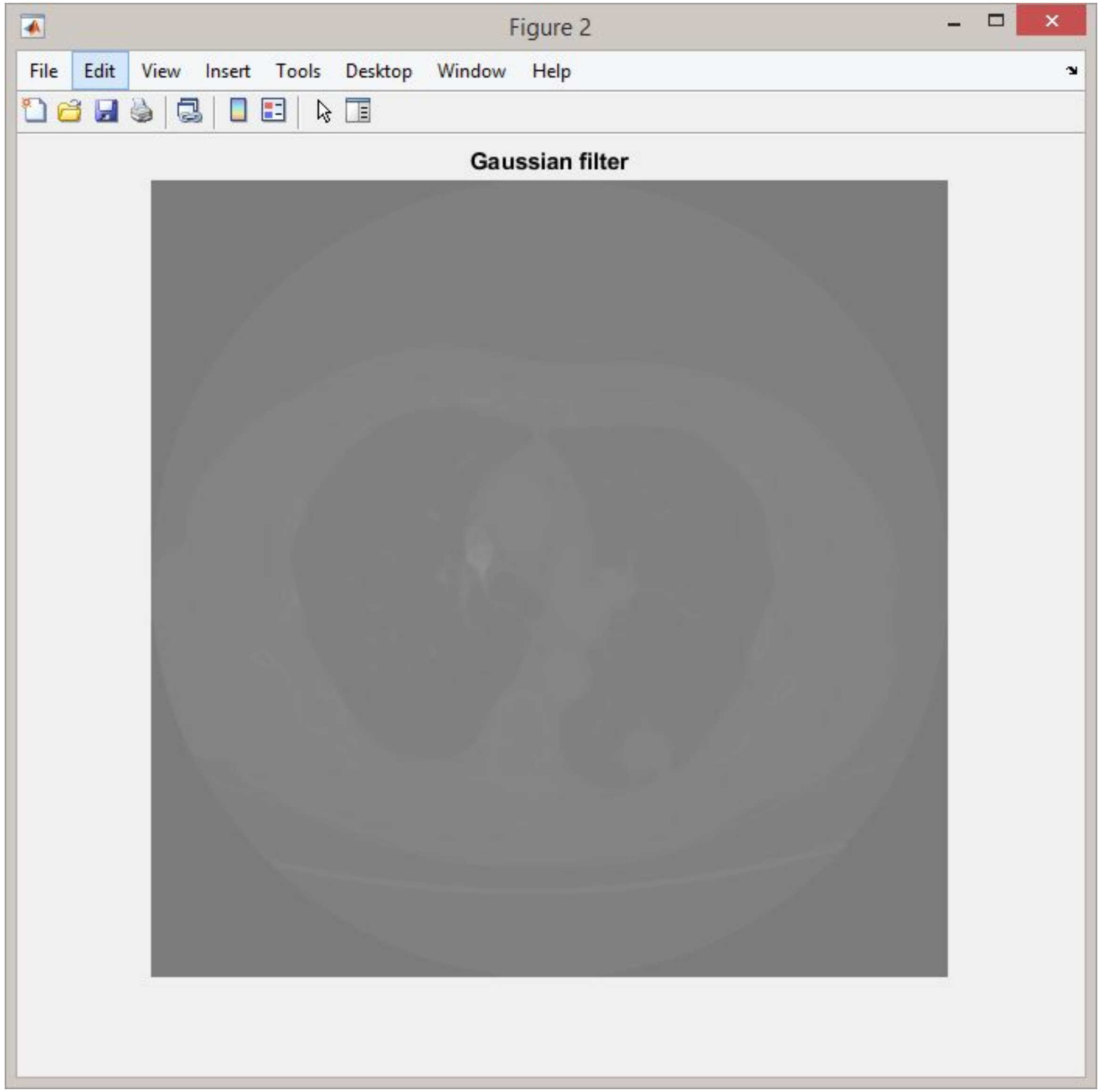
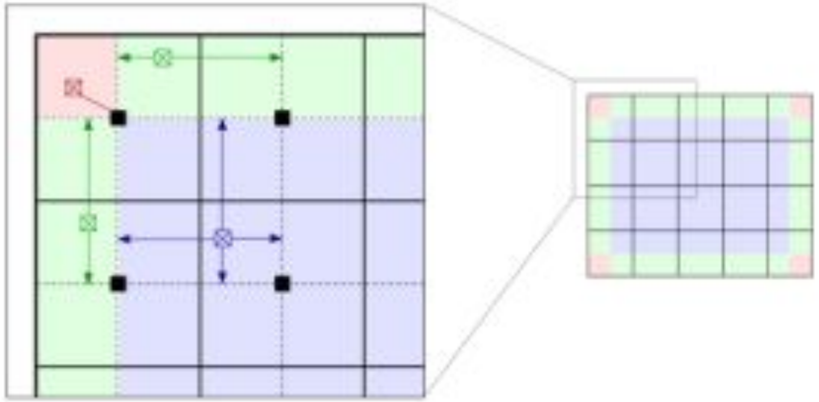
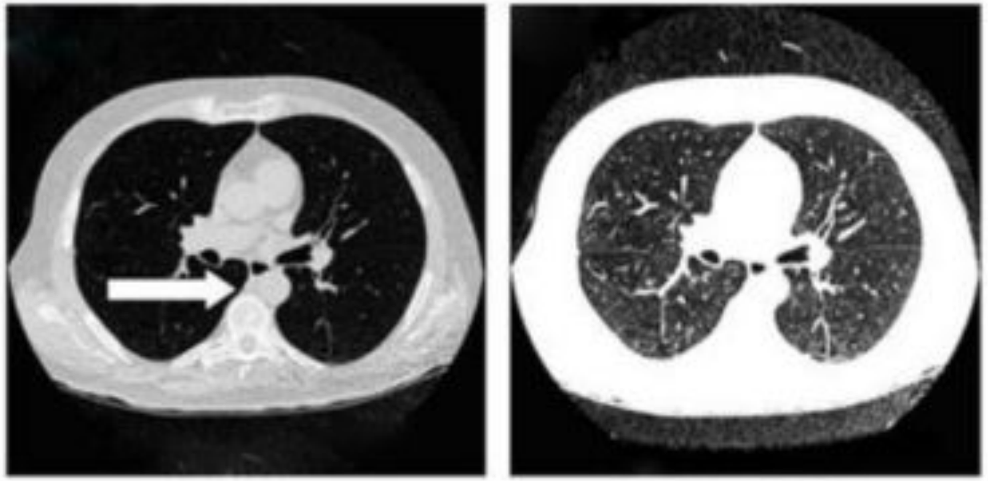


Figure 2
File Edit View Insert Tools Desktop Window Help
Gaussian filter

2^{ND} STEP: PRE-PROCESSING – IMAGE ENHANCEMENT

Function	MATLAB Code
Adaptive histogram equalization for image sharpening	J = adapthisteq(image);
Gabor filter	gb = gabor_fn(bw,gamma,psi(1),lambda,theta)... + gabor_fn(bw,gamma,psi(2),lambda,theta);





(a) Original Image (b) Enhanced by Gabor


Figure 4
File Edit View Insert Tools Desktop Window Help
Original Image

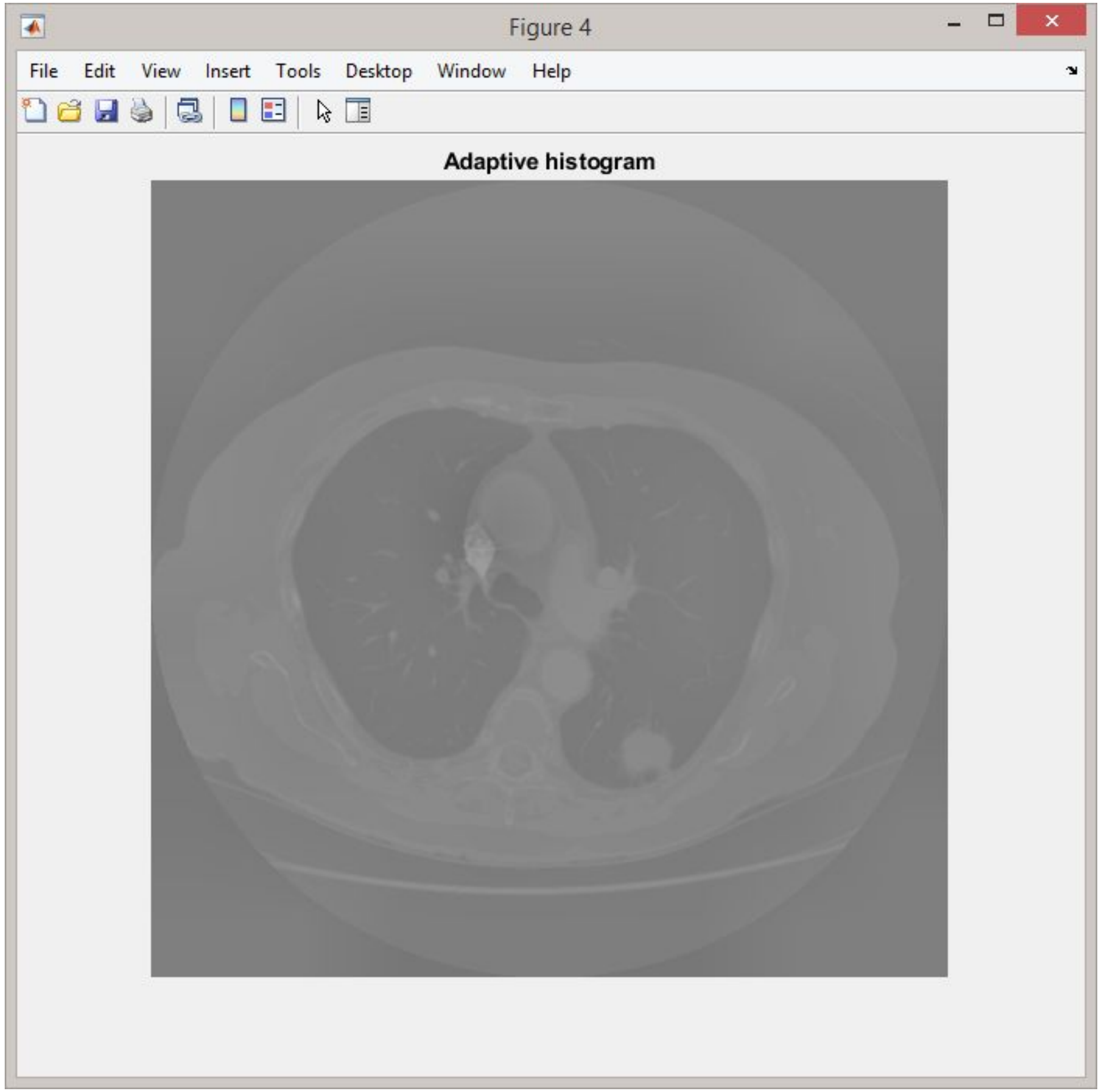


Figure 4
File Edit View Insert Tools Desktop Window Help
Adaptive histogram


Figure 4
File Edit View Insert Tools Desktop Window Help
Original Image

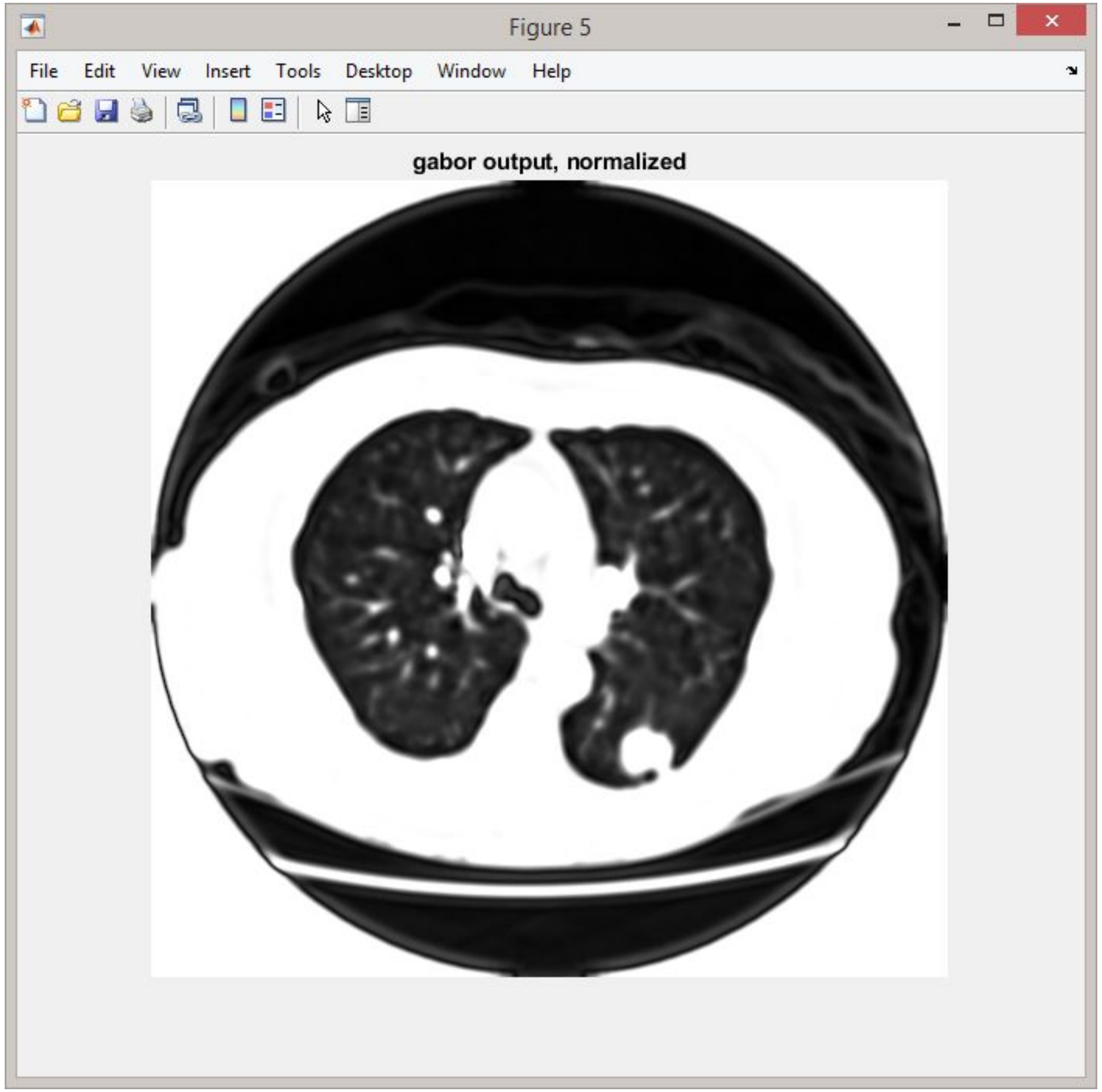



Figure 5
File Edit View Insert Tools Desktop Window Help
gabor output, normalized

2^{ND} STEP: PRE-PROCESSING – IMAGE SEGMENTATION TO OBTAIN LUNG VOLUME

- Region Based Active Contour Segmentation
- Introduced by Chan Vese in the paper: "Active Contours Without Edges"
- Used the library that is coded by Shawn Lankton
- To segment images whose foregrounds and backgrounds are statistically different and homogeneous.

(a) Enhanced by Gabor

(b) Segmented Image

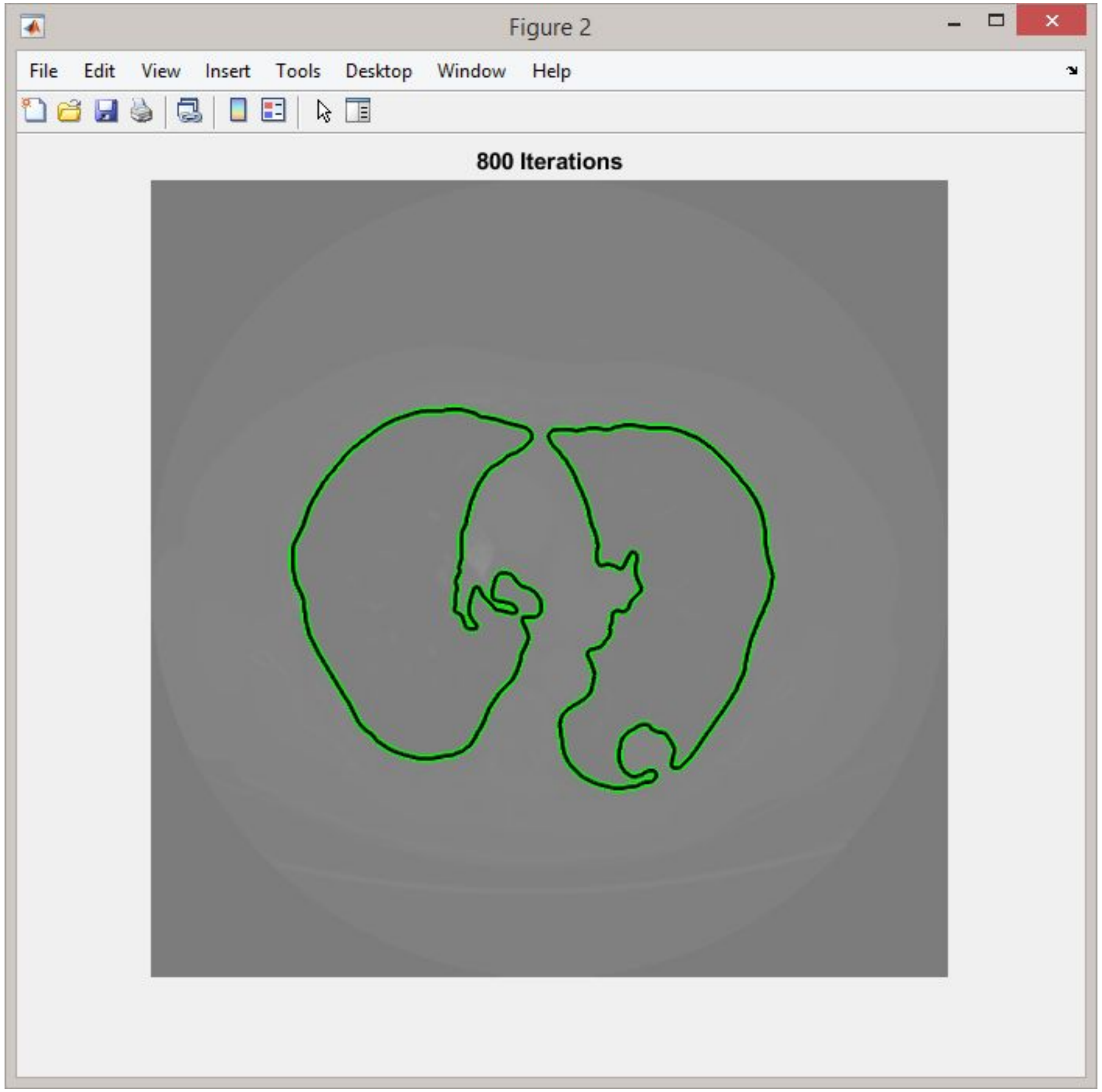


Figure 2
File Edit View Insert Tools Desktop Window Help
800 Iterations

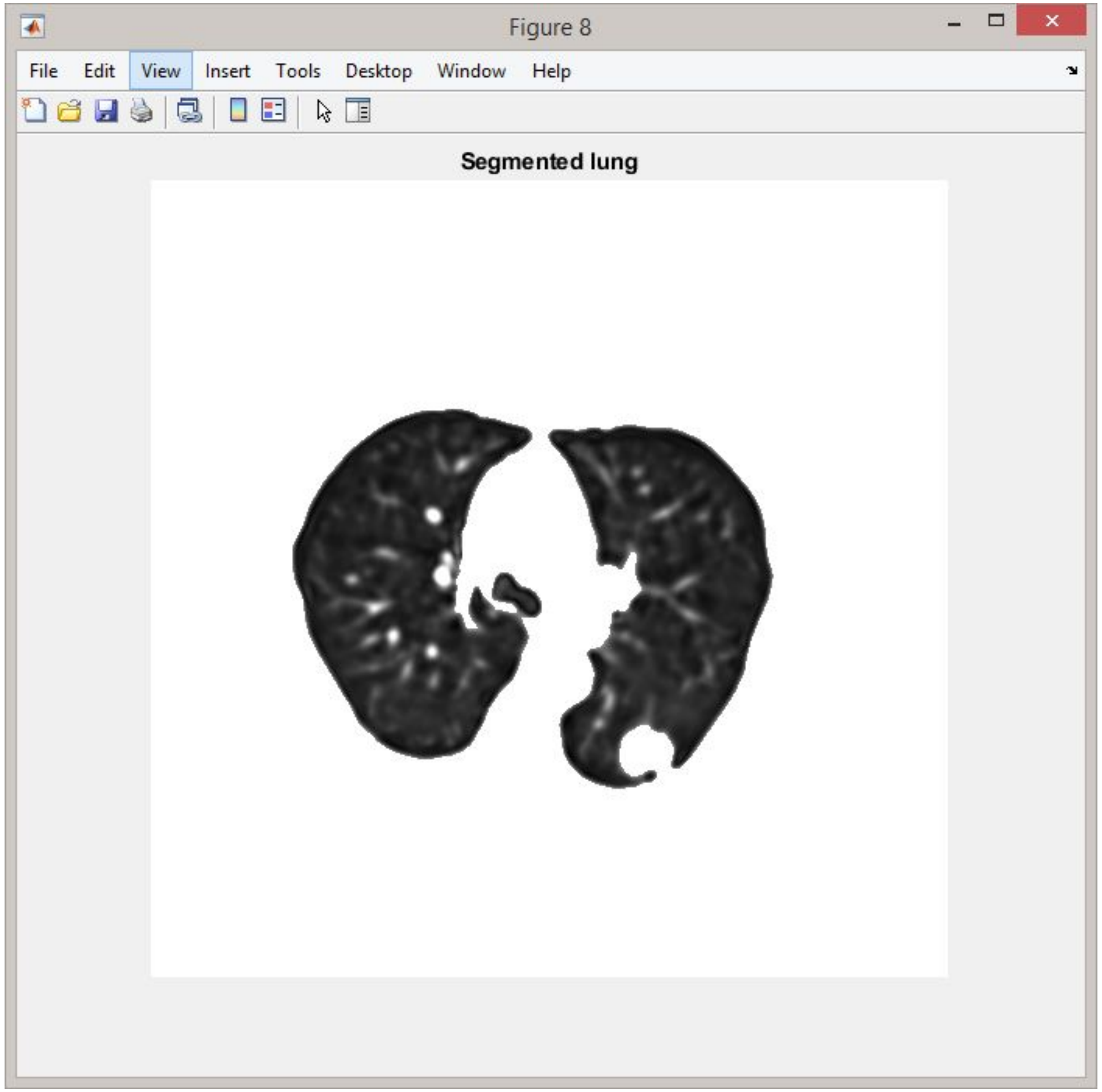


Figure 8
File Edit View Insert Tools Desktop Window Help
Segmented lung

4^{TH} STEP: GETTING RESULTS- BINARIZATION AND MASKING

- By counting the black pixels of the segmented lung images
- If number of black pixels greater than 17179*, consider normal lung
- Else consider lung cancer

*Value proven in several research papers:

Abdillah, B., Bustamam, A., & Sarwinda, D. (2016). Image processing based detection of lung cancer on CT scan images. The Asian Mathematical Conference 2016 (AMC). doi:10.1088/1742-6596/893/1/012063

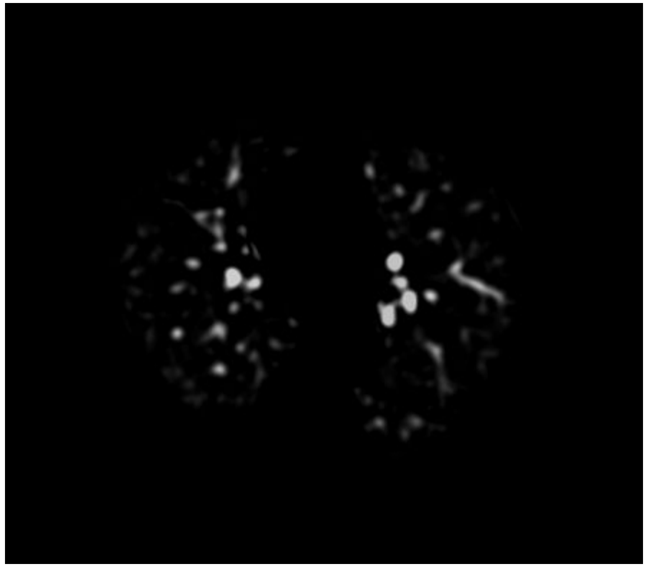
Prasad, D. V. R. (2013). Lung Cancer Detection Using Image Processing Techniques. International Journal of Latest Trends in Engineering and Technology (IJLTET).

2ND STEP: PRE-PROCESSING – OTSU THRESHOLDING TO OBTAIN LUNG NODULES

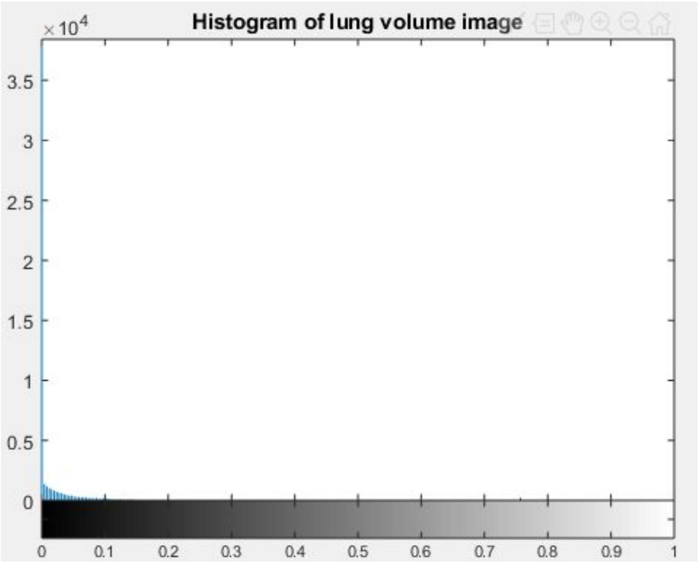
- Built-in Otsu Thresholding using MATLAB's imbinarize
- Drawbacks = Low performance when foreground objects (tumors) are small

imbinarize

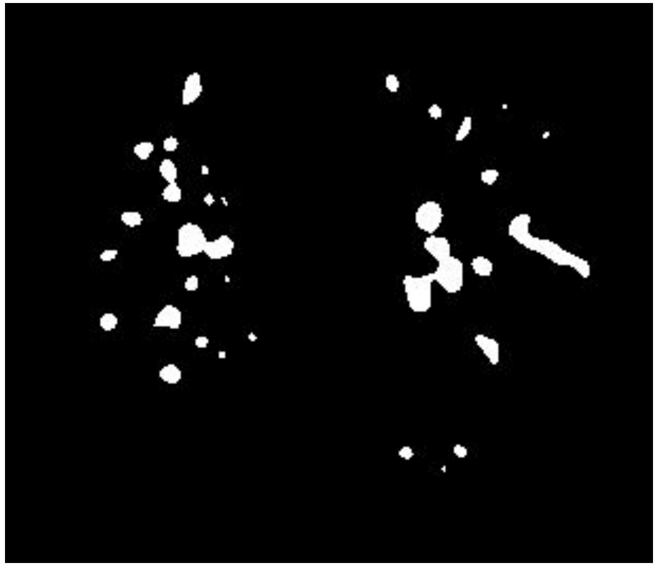
Binarize 2-D grayscale image or 3-D volume by thresholding



Segmented Lung Volume



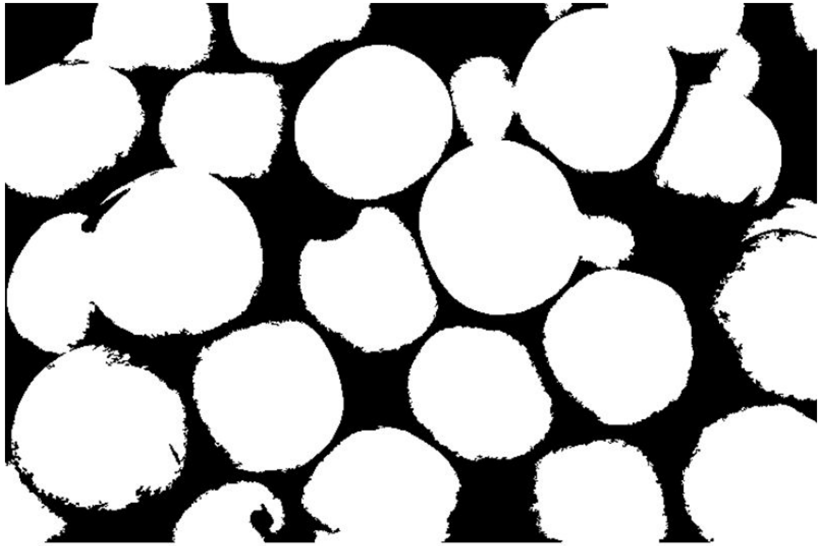
Histogram of pixel intensity



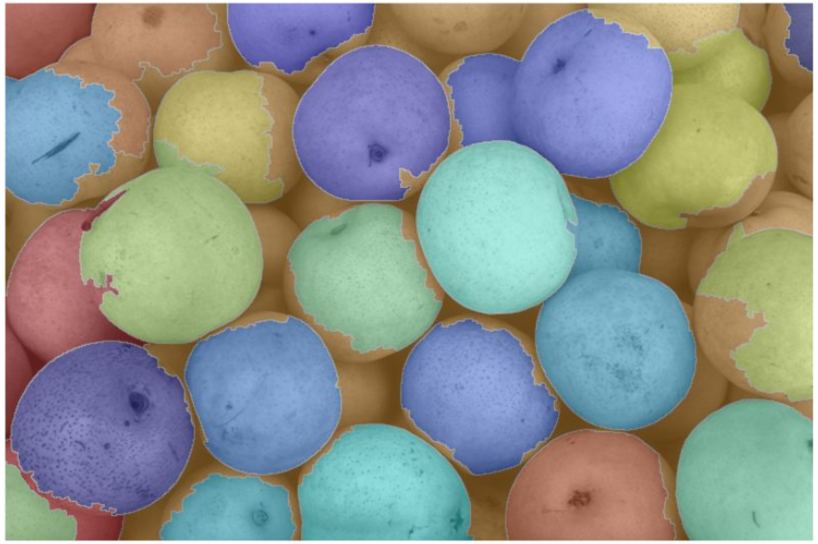
Segmented Lung Nodules

WATERSHED SEGMENTATION

Original Image



Segmented Mask using imbinarize

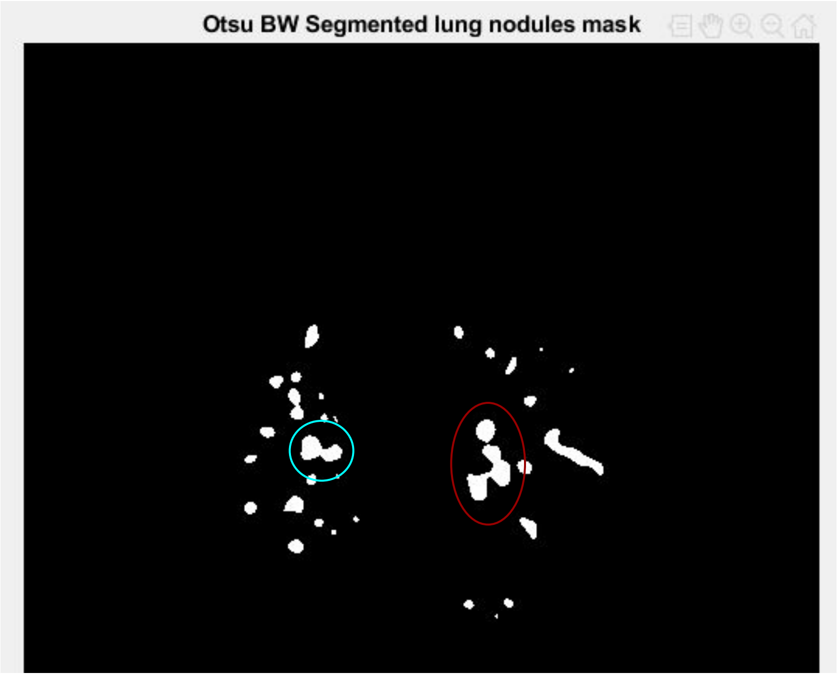


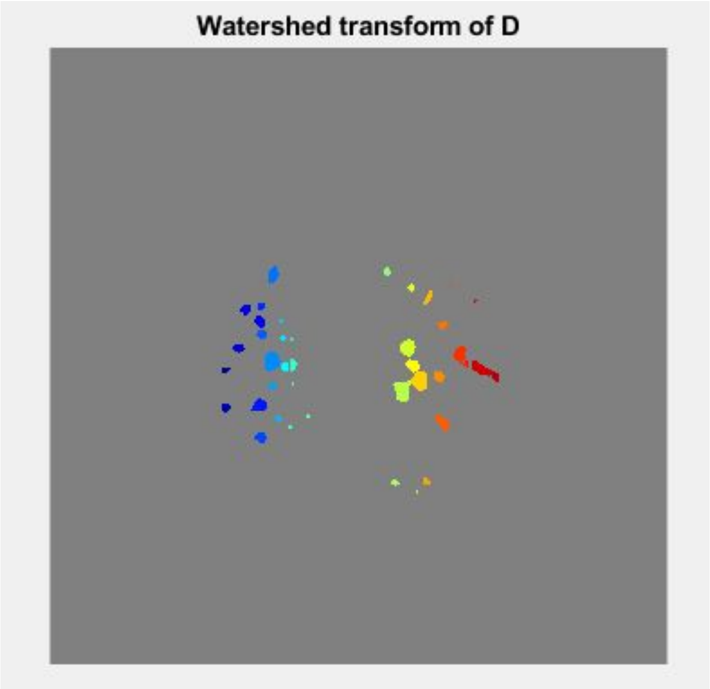
After Watershed Segmentation

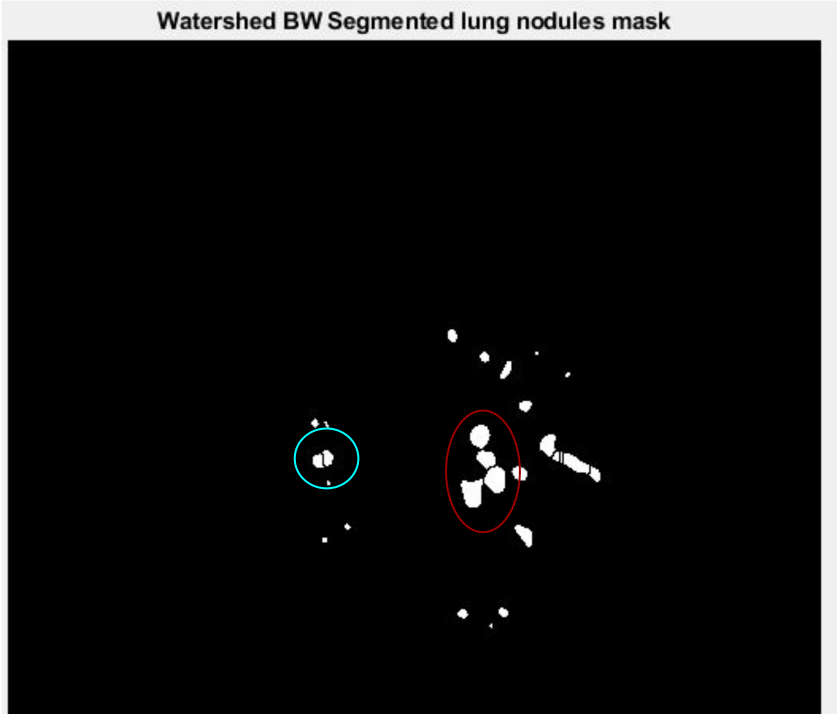
Source: MathWorks

2^{ND} STEP: PRE-PROCESSING – WATERSHED SEGMENTATION TO SEPARATE LUNG NODULES

- Connected tumors are separated using watershed segmentation.







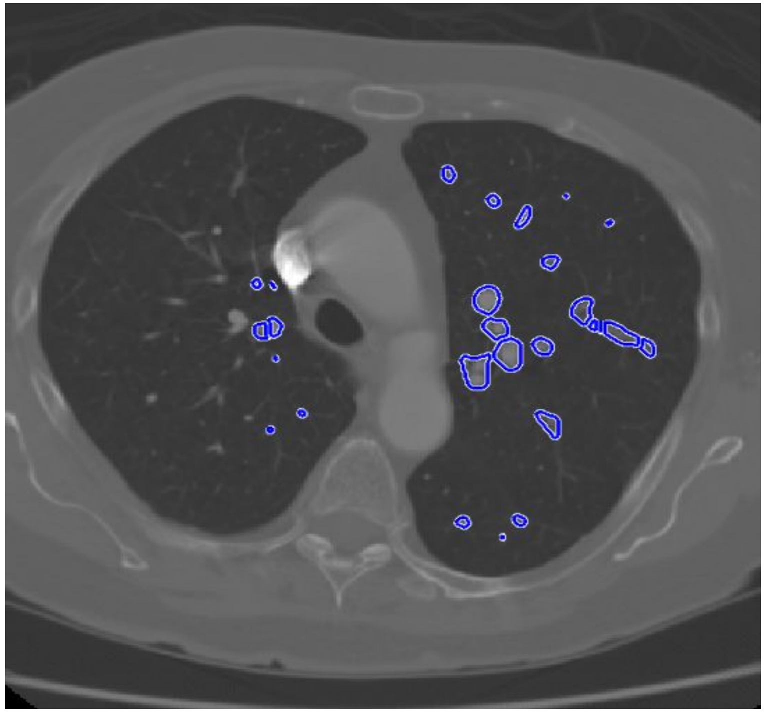
3^{RD} STEP: FEATURE EXTRACTION - GENERAL CHARACTERISTICS OF THE NODULE

Function	MATLAB Code
Obtain properties of tumour blob	conncomp = **bwconncomp**(nodulesMask); blobMeasurements=**regionprops**(conncomp, ‘'all');
Perimeter	blobPerimeter = blobMeasurements.**Perimeter**;
Area	blobArea = blobMeasurements.**Area**;
Eccentricity	blobEccentricity = blobMeasurements.**Eccentricity**;
Texture (Contrast, Correlation, Energy, Homogeneity) [NOT IMPLEMENTED]	glcms = **graycomatrix**(circuitBoard,'Offset',offsets0); stats = **graycoprops**(glcms,'Contrast Correlation');

3^{RD} STEP: FEATURE EXTRACTION - GENERAL CHARACTERISTICS OF THE NODULE

regionprops

Measure properties of image regions



stats | stats2

27x1 struct with 4 fields

Fields	Area	MajorAxisLength	Eccentricity	Perimeter
1	17	5.2944	0.5415	12.8440
2	46	9.2777	0.6893	23.3880
3	48	10.3231	0.7912	23.9670
4	9	3.4641	0	7.4760
5	6	5.1343	0.9329	7.5010
6	5	3.3066	0.7651	4.9620
7	10	4.1633	0.5923	8.6260
8	38	8.3594	0.7084	19.1950
9	28	6.4697	0.4543	16.2180
10	186	18.8877	0.6884	52.1100
11	139	14.5923	0.5423	39.8210
12	97	12.7467	0.6232	33.9990
13	29	6.7054	0.5206	16.7720
14	168	16.6837	0.6204	44.2870
15	4	3.0551	0.7319	4.5900
16	27	6.8192	0.6503	15.3660

3^{RD} STEP: FEATURE EXTRACTION - Convert Pixels to Actual Dimensions

1x1 struct with 104 fields

Field	Value
HighBit	15
BitsStored	16
BitsAllocated	16
PixelSpacing	[0.7031;0.7031]
Columns	512
Rows	512
PhotometricInterp...	'MONOCHROME2'
SamplesPerPixel	1
SliceLocation	-100
PositionReferenceI...	'SN'
FrameOfReference...	'1.3.6.1.4.1.14519.5.2.1.6279.
ImageOrientation...	[1;0;0;0;1;0]
ImagePositionPati...	[-166;-171.7000;-100]
InstanceNumber	37
SeriesNumber	3000566

Various metadata could be obtained from DICOM header

Digital Imaging and Communications in Medicine (DICOM) medical CT images are provided from the LIDC datasets.

Actual dimensions of blobs are calculated from the pixel spacing value obtained from DICOM header

```
dinfo = dicominfo('TheFileName.dcm');
spacing = dinfo.PixelSpacing;
per_pixel_area = spacing(1) * spacing(2);
```

4^{TH} STEP: GETTING RESULTS

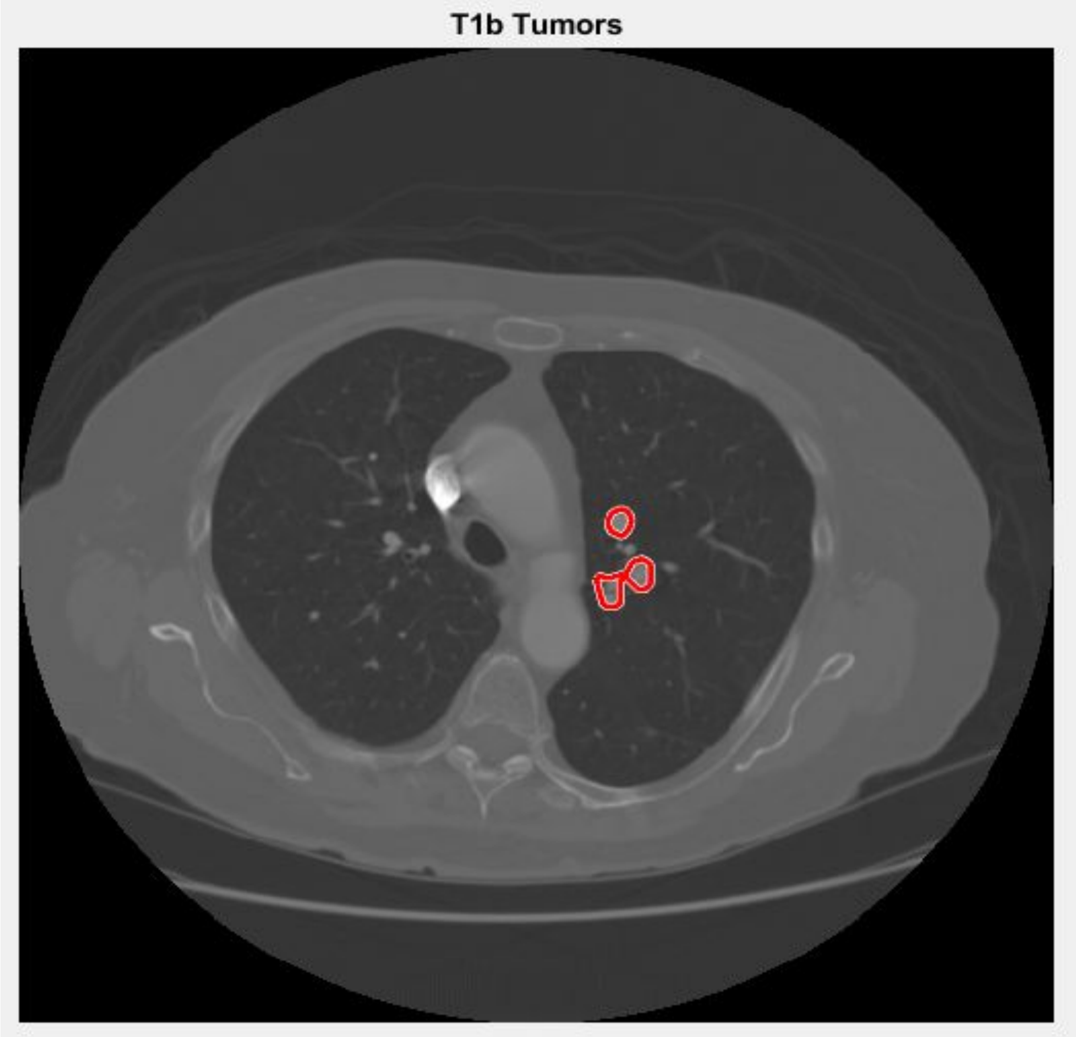
- Nodules are staged based on American Joint Committee on Cancer (AJCC) **TNM 8th edition.**

T_1	≤ 3 cm surrounded by lung/visceral pleura, not involving main bronchus
$T_{1a(mi)}$	Minimally invasive carcinoma
T_{1a}	≤ 1 cm
T_{1b}	> 1 to ≤ 2 cm
T_{1c}	> 2 to ≤ 3 cm
T_2	> 3 to ≤ 5 cm *or* involvement of main bronchus without carina, regardless of distance from carina or invasion visceral pleural *or* atelectasis or post obstructive pneumonitis extending to hilum
T_{2a}	>3 to ≤4cm
T_{2b}	>4 to ≤5cm
T_3	>5 to ≤7cm in greatest dimension *or* tumor of any size that involves chest wall, pericardium, phrenic nerve *or* satellite nodules in the same lobe

- **Tumor (T):** How large is the tumor? Has it grown into nearby structures or organs?
- **Lymph Nodes (N):** Has the cancer spread to nearby lymph nodes?
- **Metastasis (M):** Has the cancer spread to distant organs?

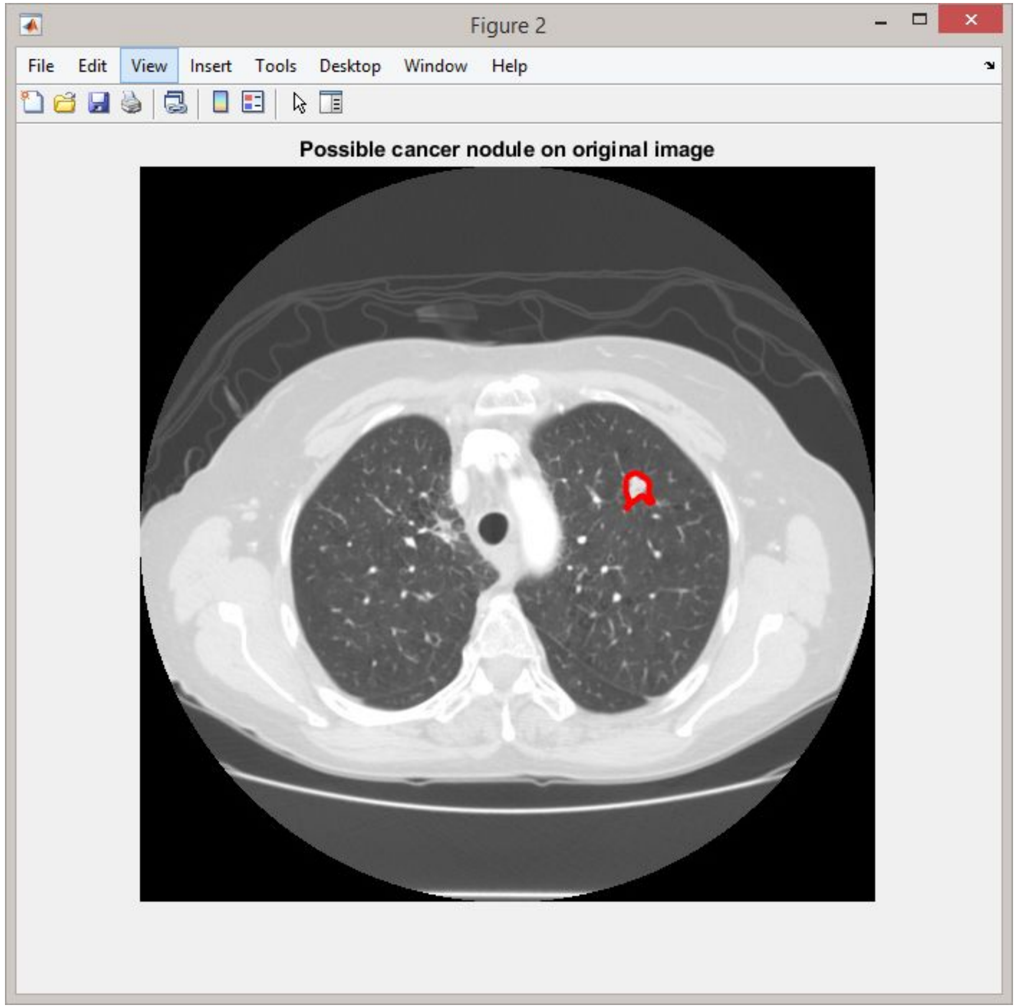
- We classify tumors based on its greatest diameter as stated in T component..

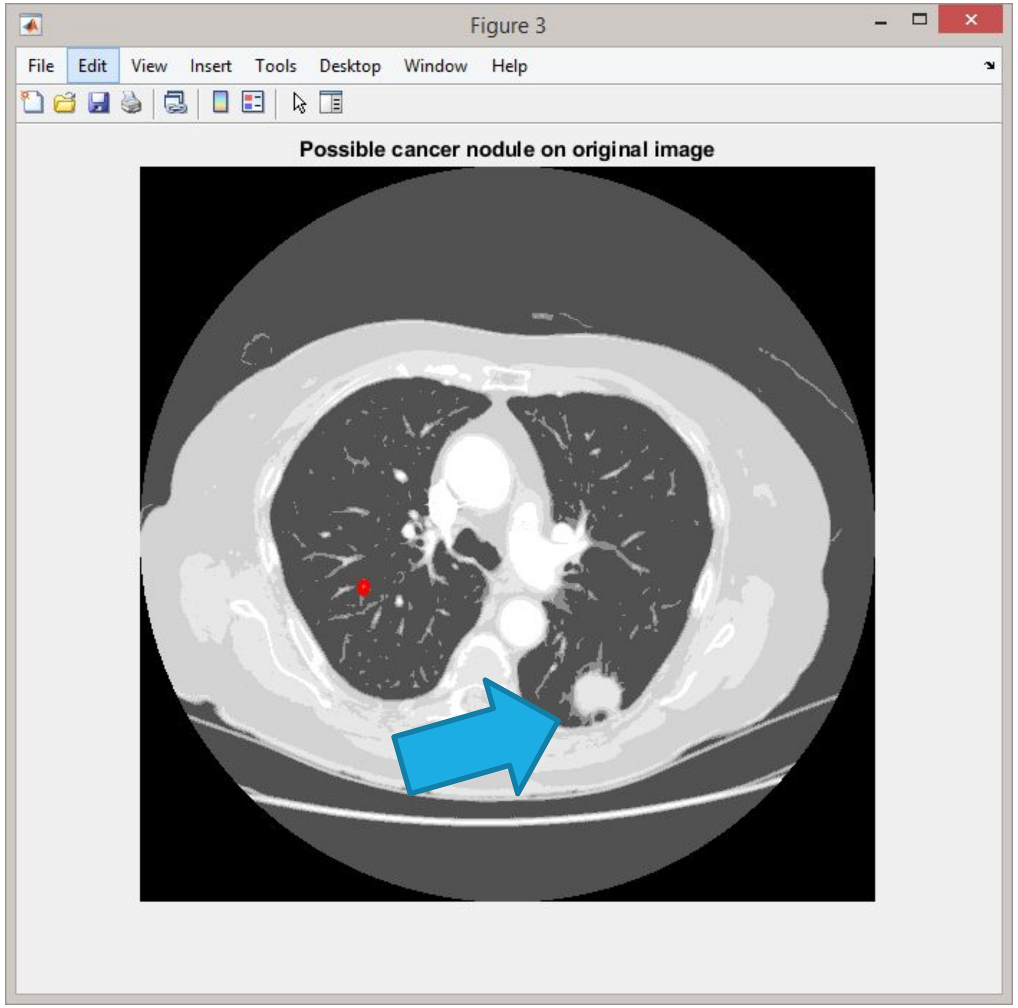
4^{TH} STEP: GETTING RESULTS




```
ans =

    'tumor detected'

Nodule # 1
Diameter of nodule/tumor =  13.3 mm
Mean Intensity of Pixels =    766.5
Blob Area (mm^2) =            92.0
Blob Perimeter (mm) =         36.6
Centroid Coordinates (x,y) = (293.0, 285.3)

Nodule # 2
Diameter of nodule/tumor =  10.3 mm
Mean Intensity of Pixels =    869.5
Blob Area (mm^2) =            68.7
Blob Perimeter (mm) =         28.0
Centroid Coordinates (x,y) = (297.8, 249.7)

Nodule # 3
Diameter of nodule/tumor =  11.7 mm
Mean Intensity of Pixels =    855.0
Blob Area (mm^2) =            83.1
Blob Perimeter (mm) =         31.1
Centroid Coordinates (x,y) = (307.7, 277.0)
```

**Extra Feature: (NOT USING) - Subpleural nodules





LIMITATIONS & DISCUSSION

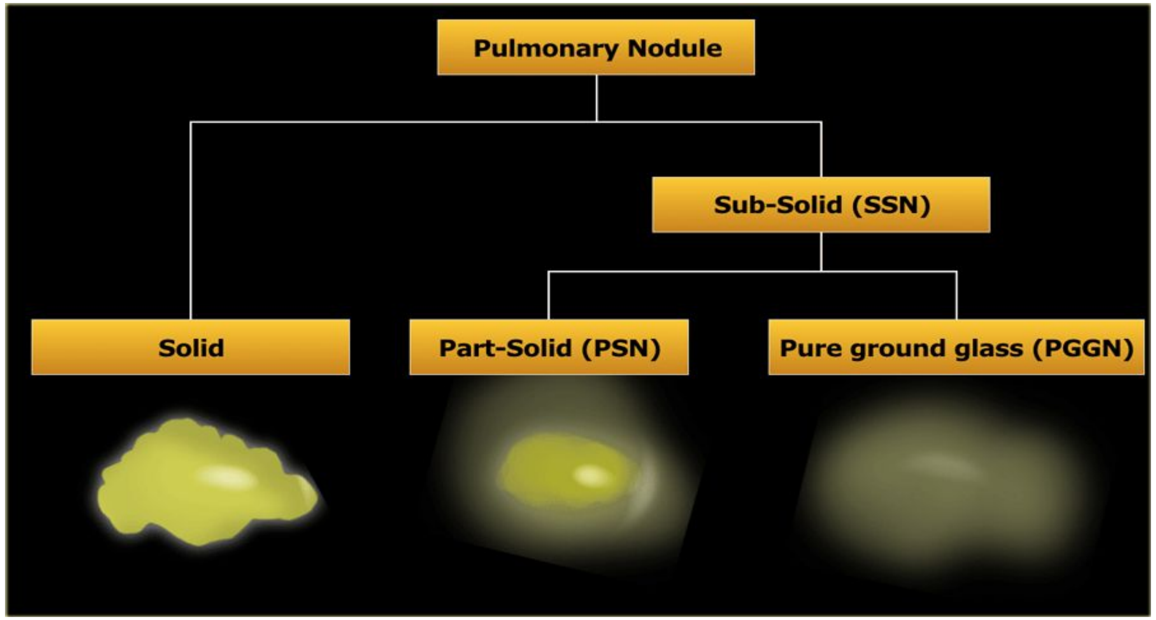
1. Unable to detect subpleural nodules for some of the lung cancer images we have – decided to remove the function instead

2. Have to use libraries that have developed by other researchers for Gabor Filter and Region Based Active Contour segmentation algorithms.

LIMITATIONS & DISCUSSION

3. Undetected small, ground-glass nodules

- Due to difficult segmentation, poorly defined borders and low contrast.



4. Only a single CT slice is analysed

- High false positives as might be a blood vessel

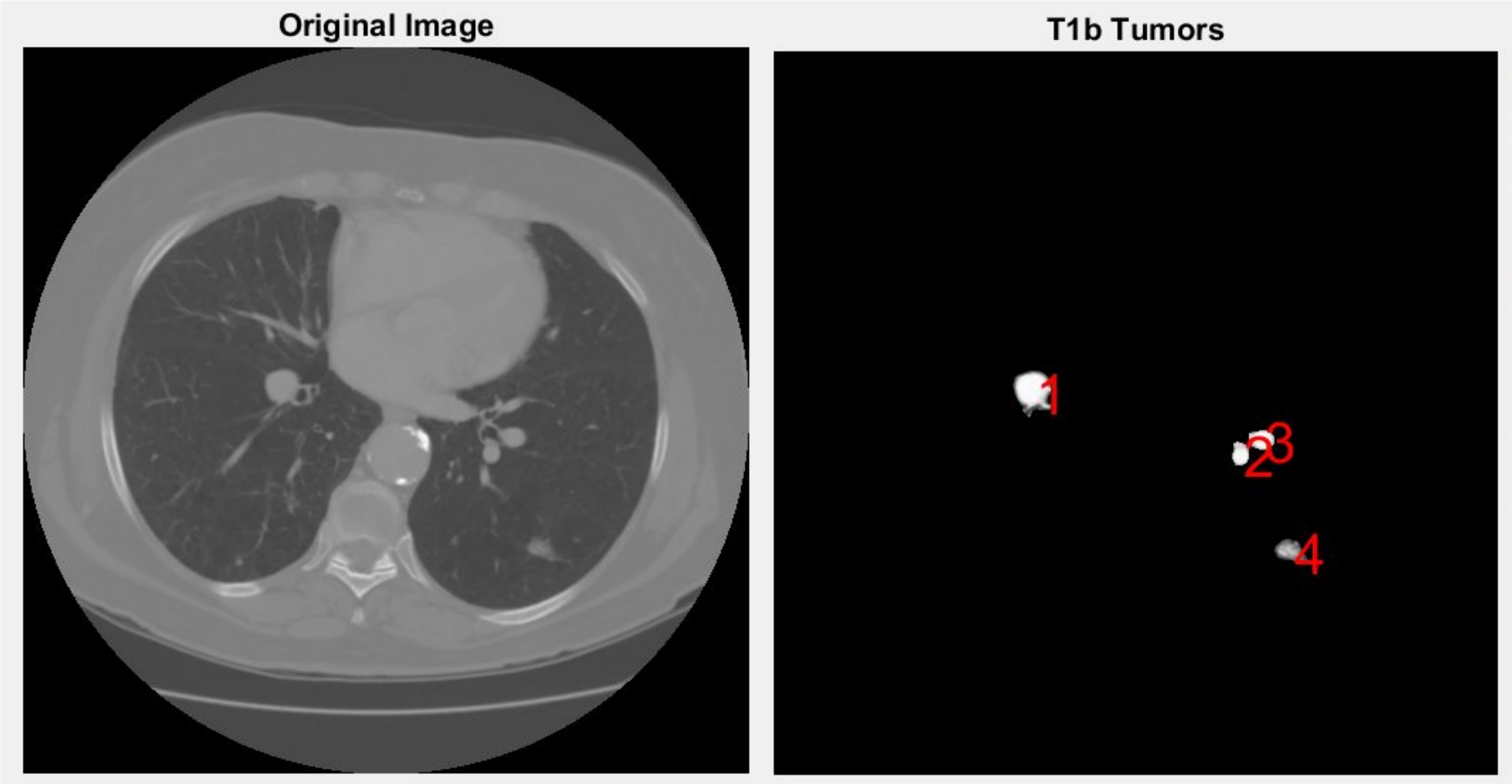
TASK DISTRIBUTION

Criteria	Work Distribution
Introduction/ background	Background = Hui Ling Motivation = Hui Ling & Yi Chang
Project aims/ objectives	Aims = Hui Ling
Literature Review	2.1 Pre-processing = Hui Ling 2.2 Feature Extraction = Yi Chang & Hui Ling
Design/ Methodology	3.1 Overall System Architecture = Hui Ling 3.2 Image Acquisition = Hui Ling & Yi Chang 3.3 Pre-processing = Hui Ling & Yi Chang 3.4 Feature Extraction = Yi Chang & Hui Ling
Limitations and discussion	Limitations = Hui Ling & Yi Chang
References	Hui Ling & Yi Chang
Report format	Hui Ling & Yi Chang

DEMO

Undefined = Patient 6 Slice #69

[Tumor (5) and Non Tumor (1-3) Detected]



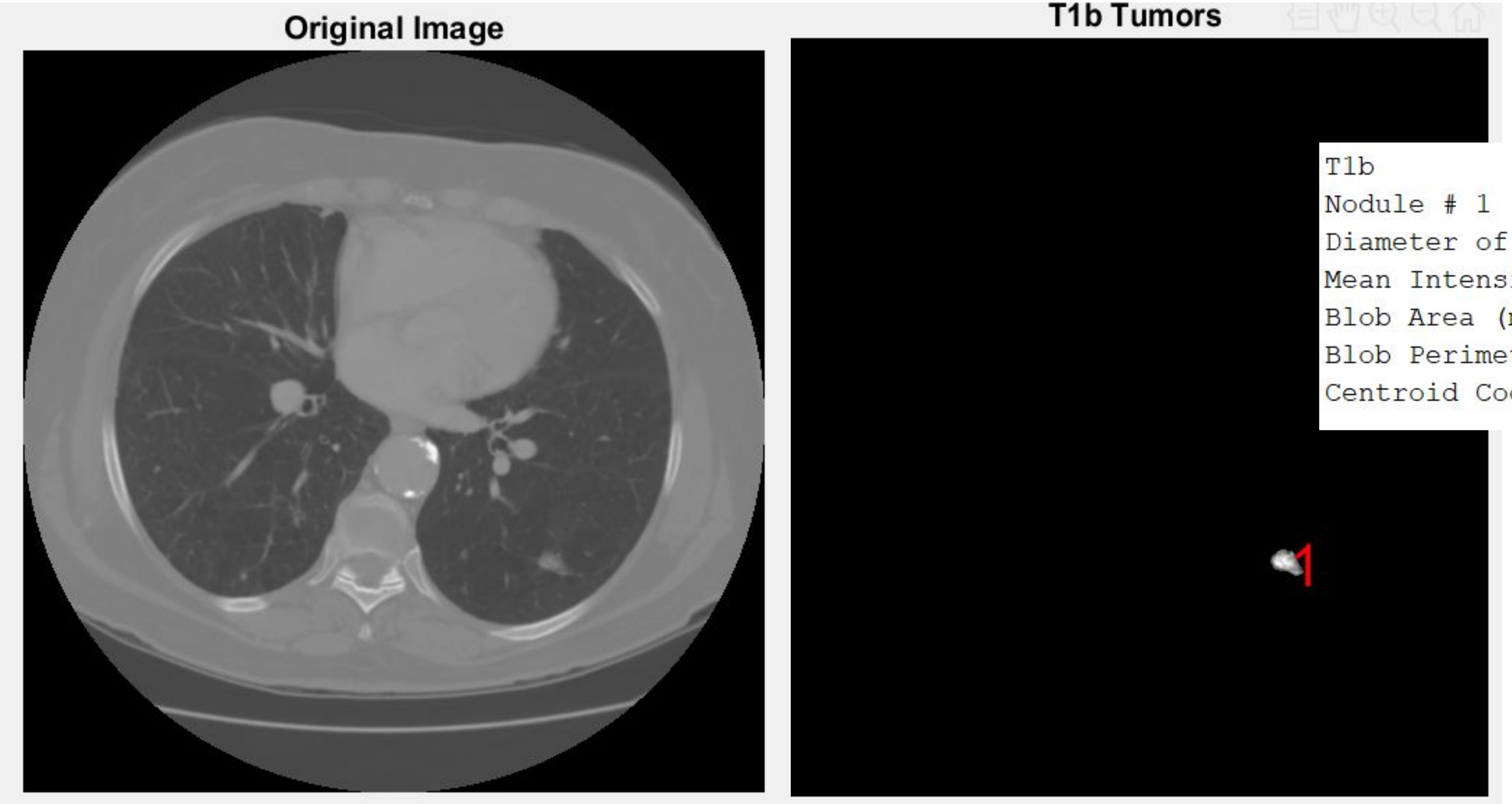
Non Tumor

```
T1b
Nodule # 1
Diameter of nodule/tumor =  19.9 mm
Mean Intensity of Pixels =    915.9
Blob Area (mm^2) =           257.8
Blob Perimeter (mm) =         62.9
Centroid Coordinates (x,y) = (183.7, 241.0)

Nodule # 2
Diameter of nodule/tumor =  10.8 mm
Mean Intensity of Pixels =   1034.2
Blob Area (mm^2) =            64.8
Blob Perimeter (mm) =         28.0
Centroid Coordinates (x,y) = (330.5, 285.3)

Nodule # 3
Diameter of nodule/tumor =  11.7 mm
Mean Intensity of Pixels =   1053.7
Blob Area (mm^2) =            80.5
Blob Perimeter (mm) =         30.8
Centroid Coordinates (x,y) = (345.5, 275.4)
```

Tumor

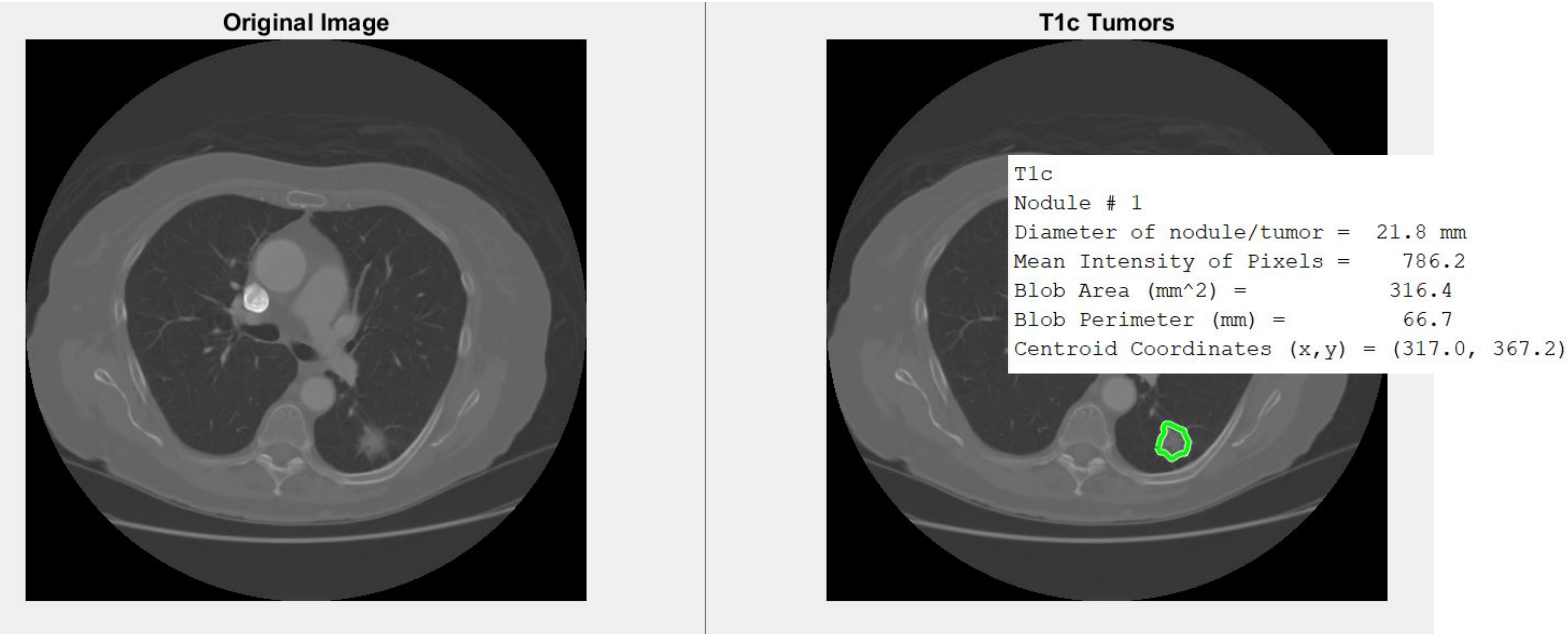
```
Nodule # 4
Diameter of nodule/tumor =  15.4 mm
Mean Intensity of Pixels =    588.6
Blob Area (mm^2) =           110.5
Blob Perimeter (mm) =         38.9
Centroid Coordinates (x,y) = (366.1, 354.5)
```

Successful = Patient 6 Slice #69 (Tumor has lower intensity than lymph nodes)

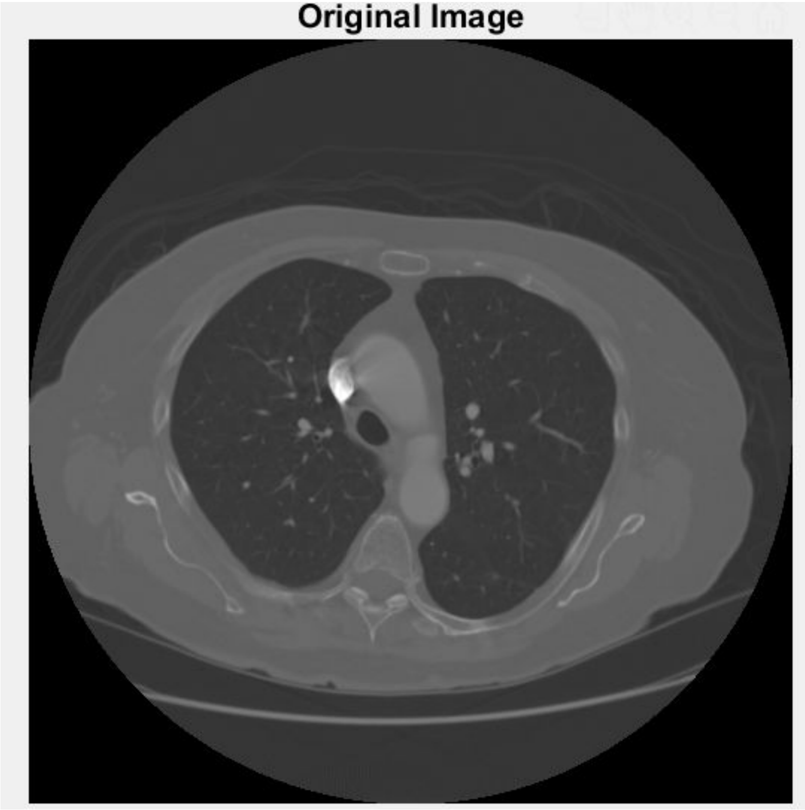


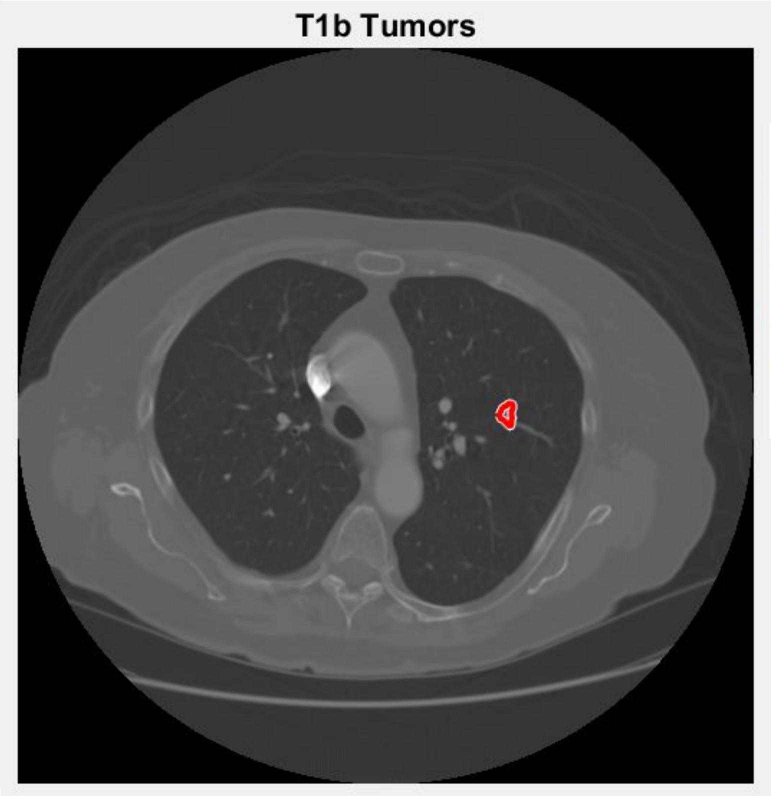

```
T1b
Nodule # 1
Diameter of nodule/tumor =  15.4 mm
Mean Intensity of Pixels =    588.6
Blob Area (mm^2) =           110.5
Blob Perimeter (mm) =         38.9
Centroid Coordinates (x,y) = (366.1, 354.5)
```

Successful - Patient 1
Slice #123



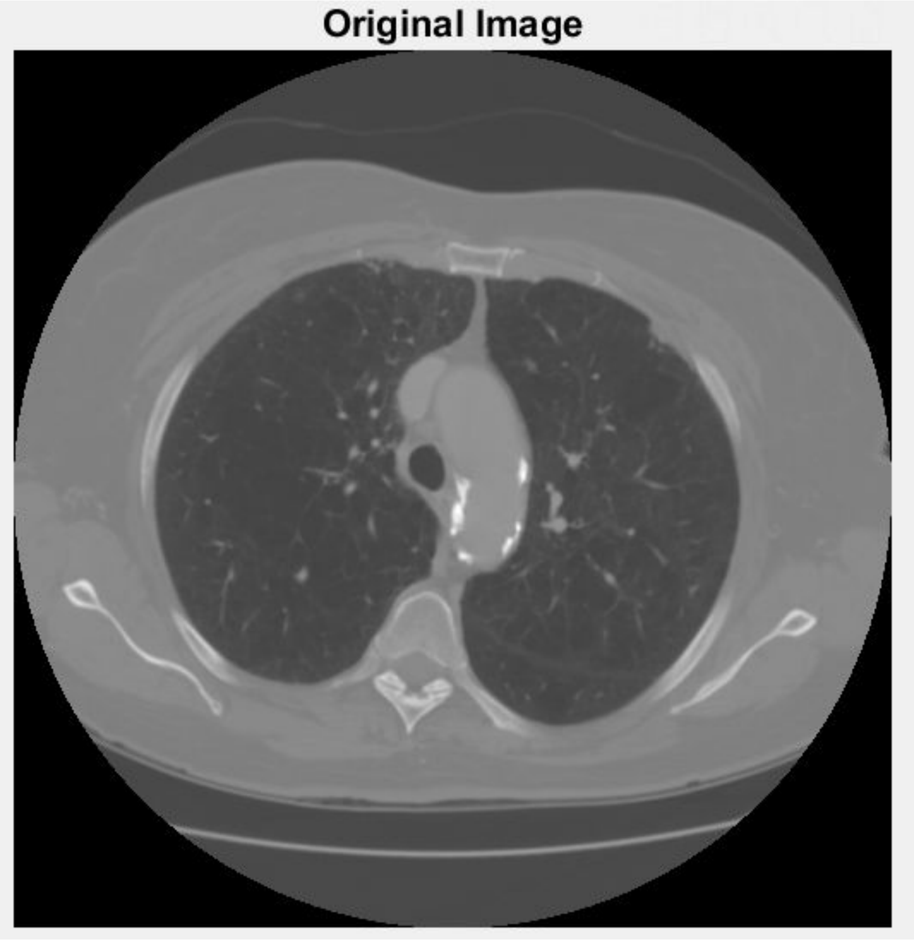
Successful = Patient 1 Slice #96

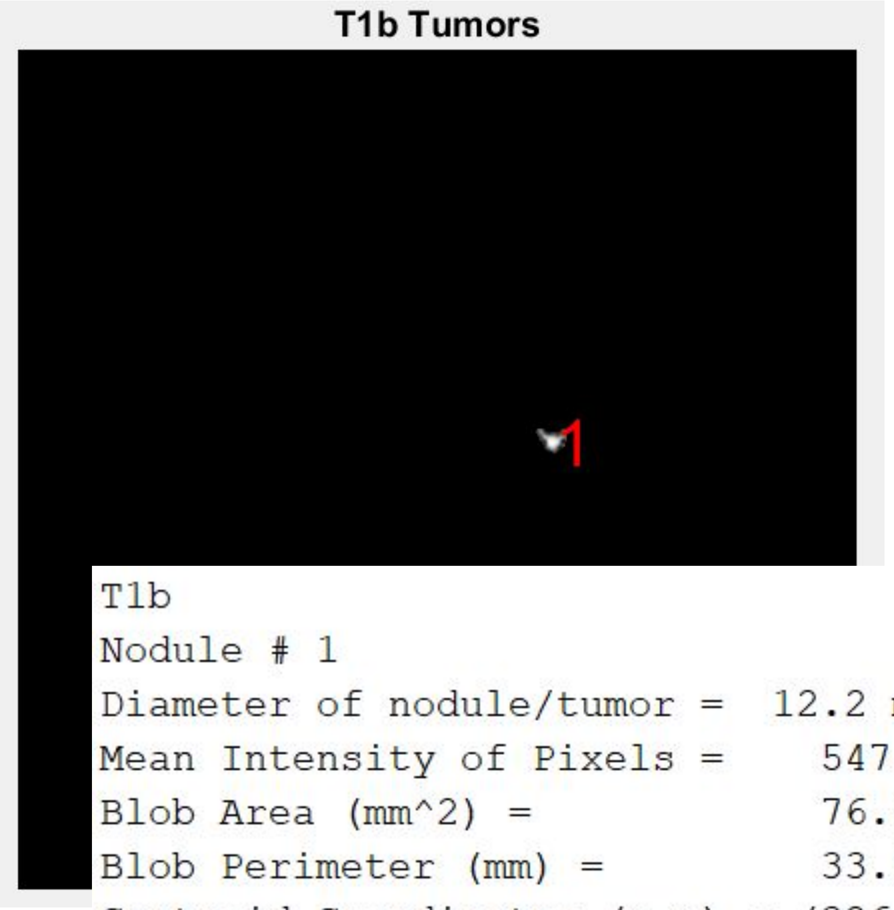





```
T1b
Nodule # 1
Diameter of nodule/tumor =  11.2 mm
Mean Intensity of Pixels =    456.5
Blob Area (mm^2) =            56.4
Blob Perimeter (mm) =         29.0
Centroid Coordinates (x,y) = (340.9, 255.4)
```

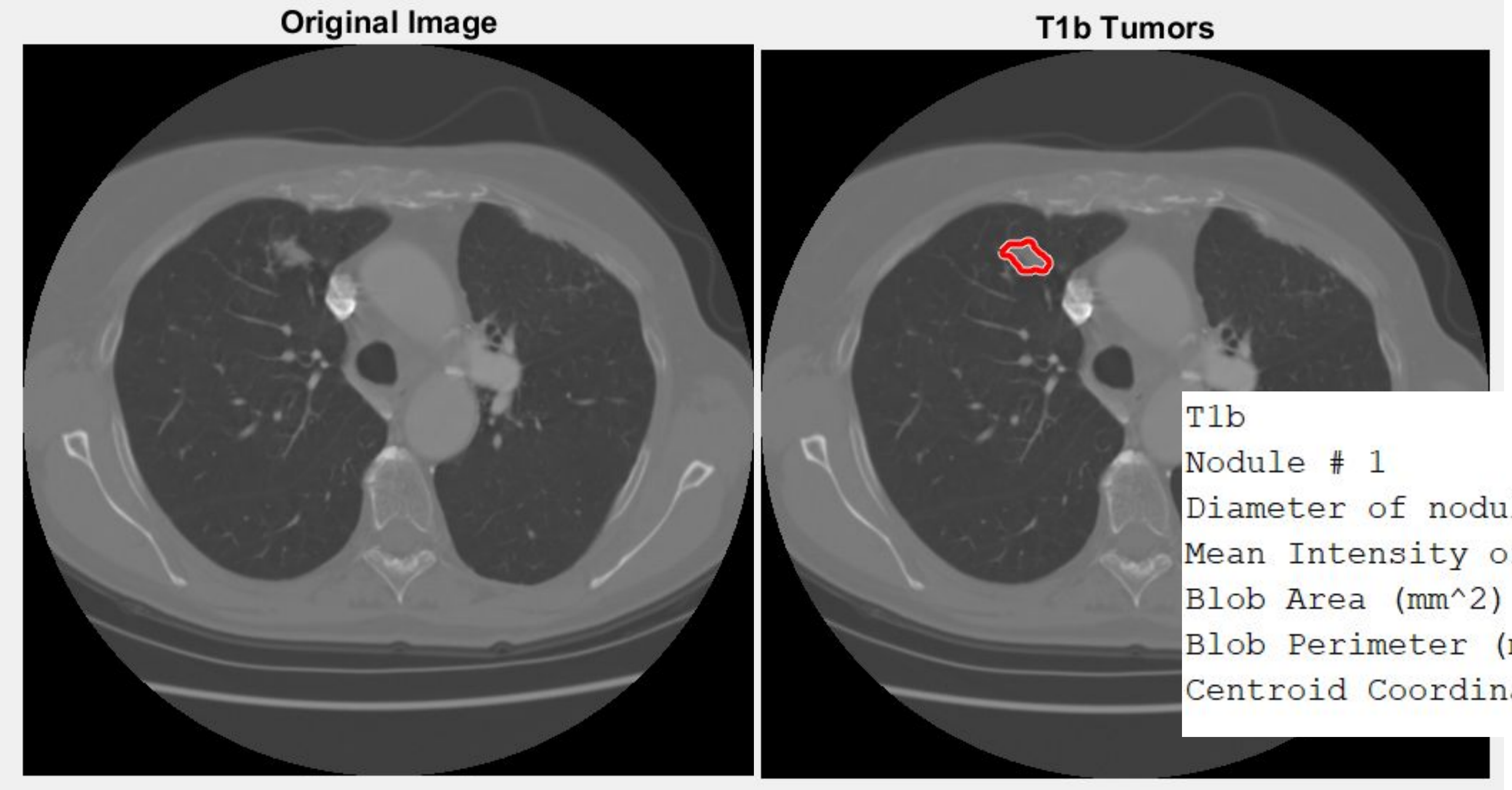
Successful = Patient 6 Slice #111





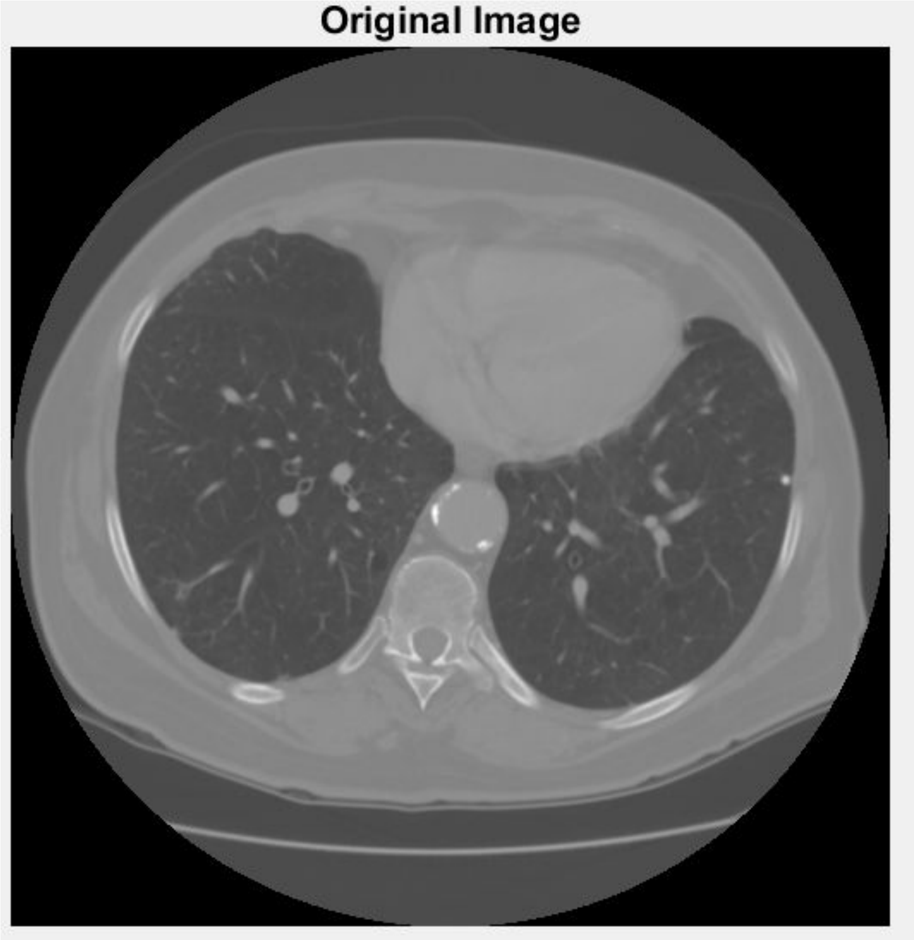

```
T1b
Nodule # 1
Diameter of nodule/tumor =  12.2 mm
Mean Intensity of Pixels =    547.3
Blob Area (mm^2) =            76.6
Blob Perimeter (mm) =         33.9
Centroid Coordinates (x,y) = (326.9, 238.3)
```

Successful = Patient 13 Slice #96



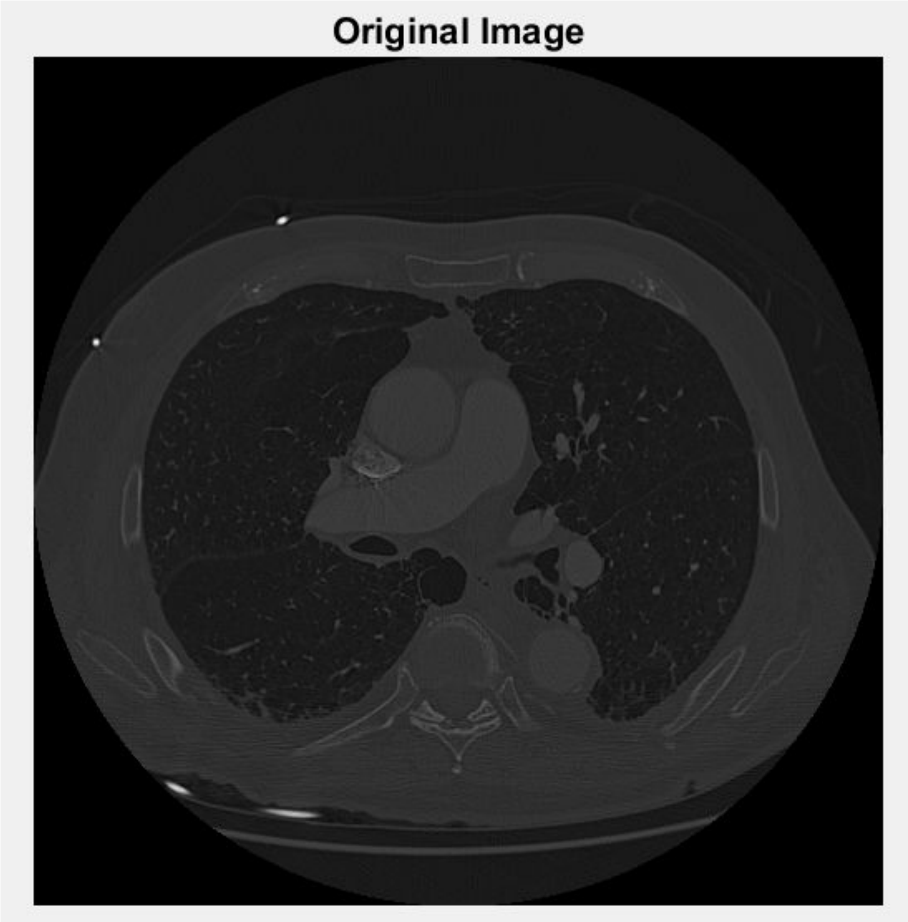

```
T1b
Nodule # 1
Diameter of nodule/tumor =  19.7 mm
Mean Intensity of Pixels =    734.1
Blob Area (mm^2) =           162.0
Blob Perimeter (mm) =         50.8
Centroid Coordinates (x,y) = (187.3, 146.1)
```

Successful (Healthy) = Patient 6 Slice #57



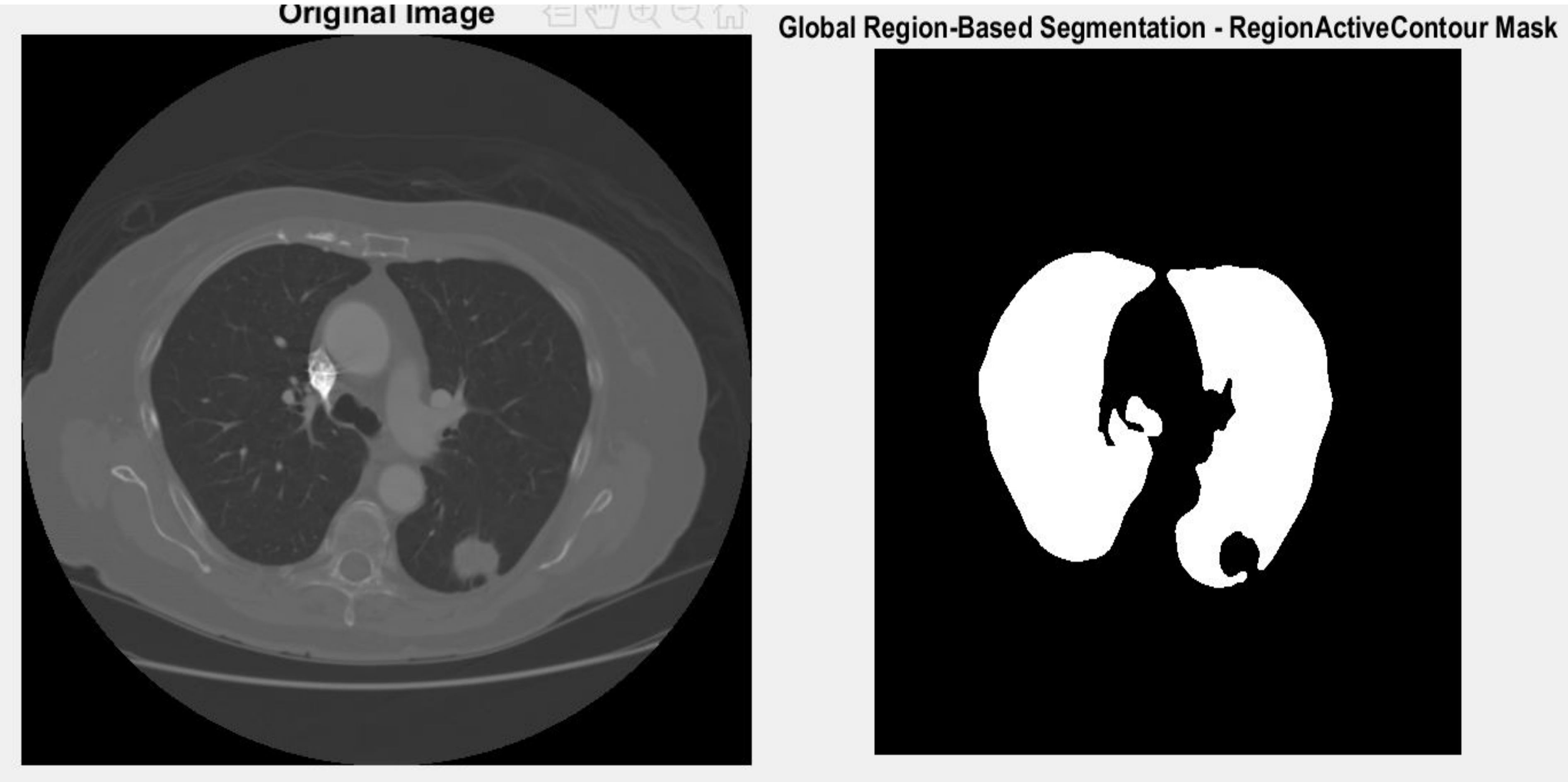

```
ans =

    'normal lung'
```

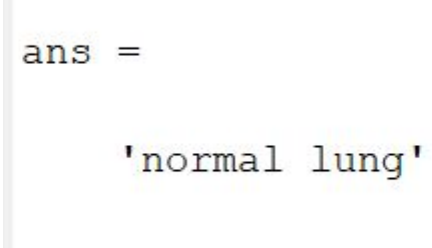
Successful (Healthy) = Patient 82 Slice #7



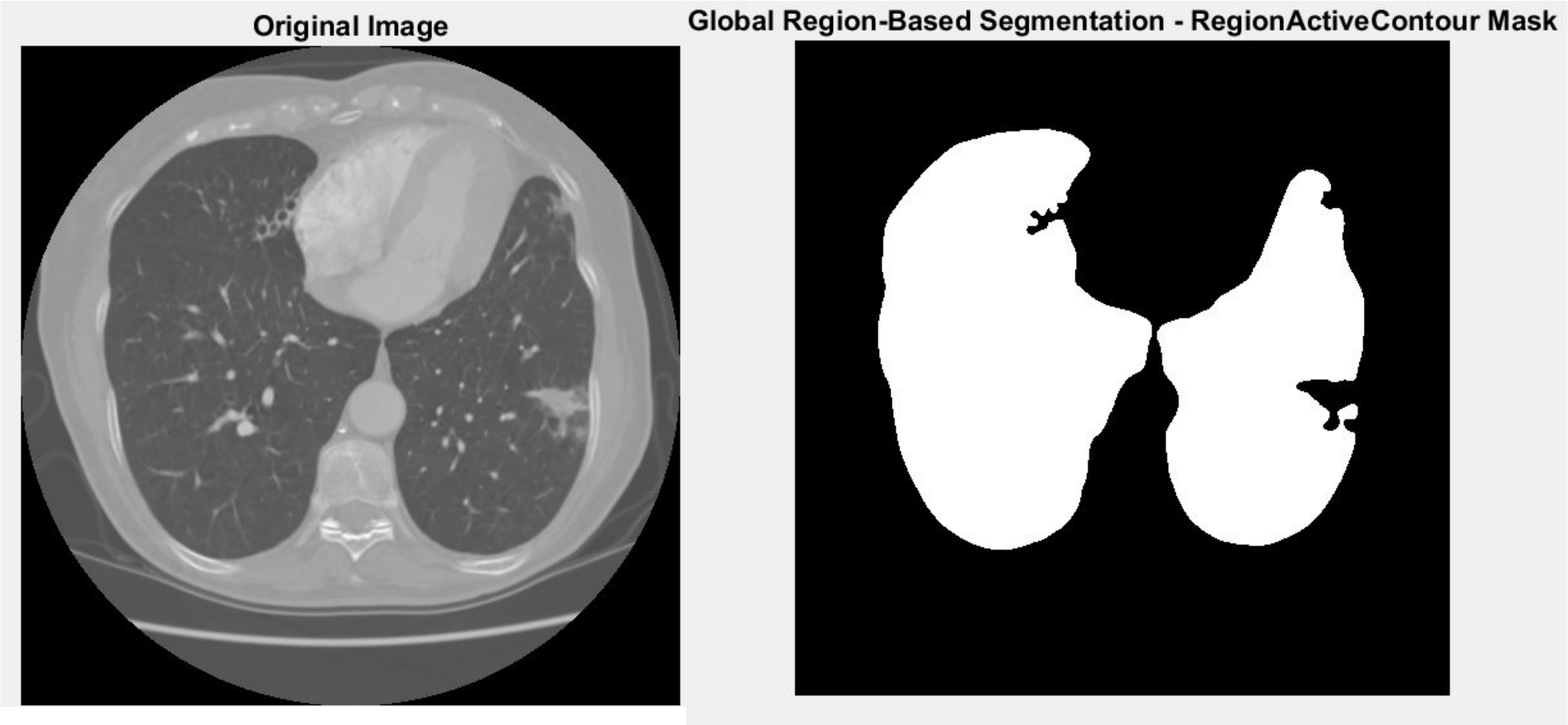

```
ans =

    'normal lung'
```

Unsuccessful = Patient 1 Slice #3 [Tumor is segmented out]





Unsuccessful = Patient 1 Slice #3 [Tumor is segmented out]




```
ans =

    'normal lung'
```