Computational Methods for Biomedical Image Analysis

Assignment 1

Medical Image Segmentation

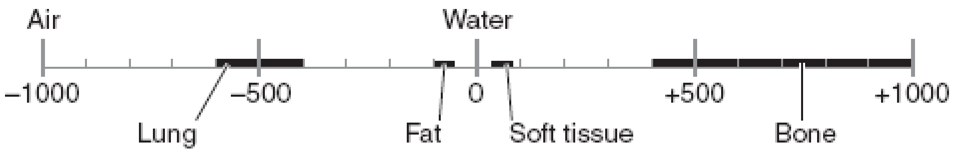
Introduction

- In this assignment, we will learn
  - Usage of DICOM (Digital Imaging and Communications in Medicine) files
  - Hounsfield Units
  - CT Segmentation using thresholding algorithm

Part 1 (10%)

- Read in and print out all the data fields in a DICOM file (one slice) (5%)
- Read in the raw data for a CT slice and convert its pixel values into Hounsfield units. Compute the max, min, mean and standard deviation of both images (raw data and Hounsfield units) (5%)

$$\text{Hounsfield Units} = \mathit{RescaleSlope} \times \text{Raw Image} + \mathit{RescaleIntercept}$$



Bone	+400 ⟶ +1000
Soft tissue	+40 ⟶ +80
Water	0
Fat	−60 ⟶ −100
Lung	−400 ⟶ −600
Air	−1000

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(0008, 0005) Specific Character Set              CS: 'ISO_IR 100'
(0008, 0016) SOP Class UID                       UI: CT Image Storage
(0008, 0018) SOP Instance UID                    UI: 1.3.6.1.4.1.14519.5.2.1.7009.9004.993926557618716725548364243182
(0008, 0060) Modality                            CS: 'CT'
(0008, 103e) Series Description                  LO: 'Axial'
(0010, 0010) Patient's Name                      PN: '0acbebb8d463b4b9ca88cf38431aac69'
(0010, 0020) Patient ID                          LO: '0acbebb8d463b4b9ca88cf38431aac69'
(0010, 0030) Patient's Birth Date                DA: '19000101'
(0018, 0060) KVP                                 DS: ''
(0020, 000d) Study Instance UID                  UI: 2.25.66234994940093060530875882673593880723182397297085825139120
(0020, 000e) Series Instance UID                 UI: 2.25.27985737130106072918310533525688877208529713445697698517643
(0020, 0011) Series Number                       IS: '4'
(0020, 0012) Acquisition Number                  IS: '2'
(0020, 0013) Instance Number                     IS: '1'
(0020, 0032) Image Position (Patient)            DS: ['-157.2275390625', '-280.2275390625', '-18.9']
(0020, 0037) Image Orientation (Patient)         DS: ['1', '0', '0', '0', '1', '0']
(0020, 0052) Frame of Reference UID              UI: 2.25.11024047567322936673371602952341875417234268835153580015625
(0020, 1040) Position Reference Indicator        LO: ''
(0020, 1041) Slice Location                      DS: "-18.9"
(0028, 0002) Samples per Pixel                   US: 1
(0028, 0004) Photometric Interpretation          CS: 'MONOCHROME2'
(0028, 0010) Rows                                US: 512
(0028, 0011) Columns                             US: 512
(0028, 0030) Pixel Spacing                       DS: ['0.544921875', '0.544921875']
(0028, 0100) Bits Allocated                      US: 16
(0028, 0101) Bits Stored                         US: 12
(0028, 0102) High Bit                            US: 11
(0028, 0103) Pixel Representation                US: 0
(0028, 0106) Smallest Image Pixel Value          US: 0
(0028, 0107) Largest Image Pixel Value           US: 4090
(0028, 0301) Burned In Annotation                CS: 'NO'
(0028, 0303) Longitudinal Temporal Information M SH: 'MODIFIED'
(0028, 1050) Window Center                       DS: ['-400', '0']
(0028, 1051) Window Width                        DS: ['1600', '2']
(0028, 1052) Rescale Intercept                   DS: "-1024"
(0028, 1053) Rescale Slope                       DS: "1"
(0028, 1055) Window Center & Width Explanation   LO: ['WINDOW1', 'WINDOW2']
(7fe0, 0010) Pixel Data                          OW: Array of 524288 bytes
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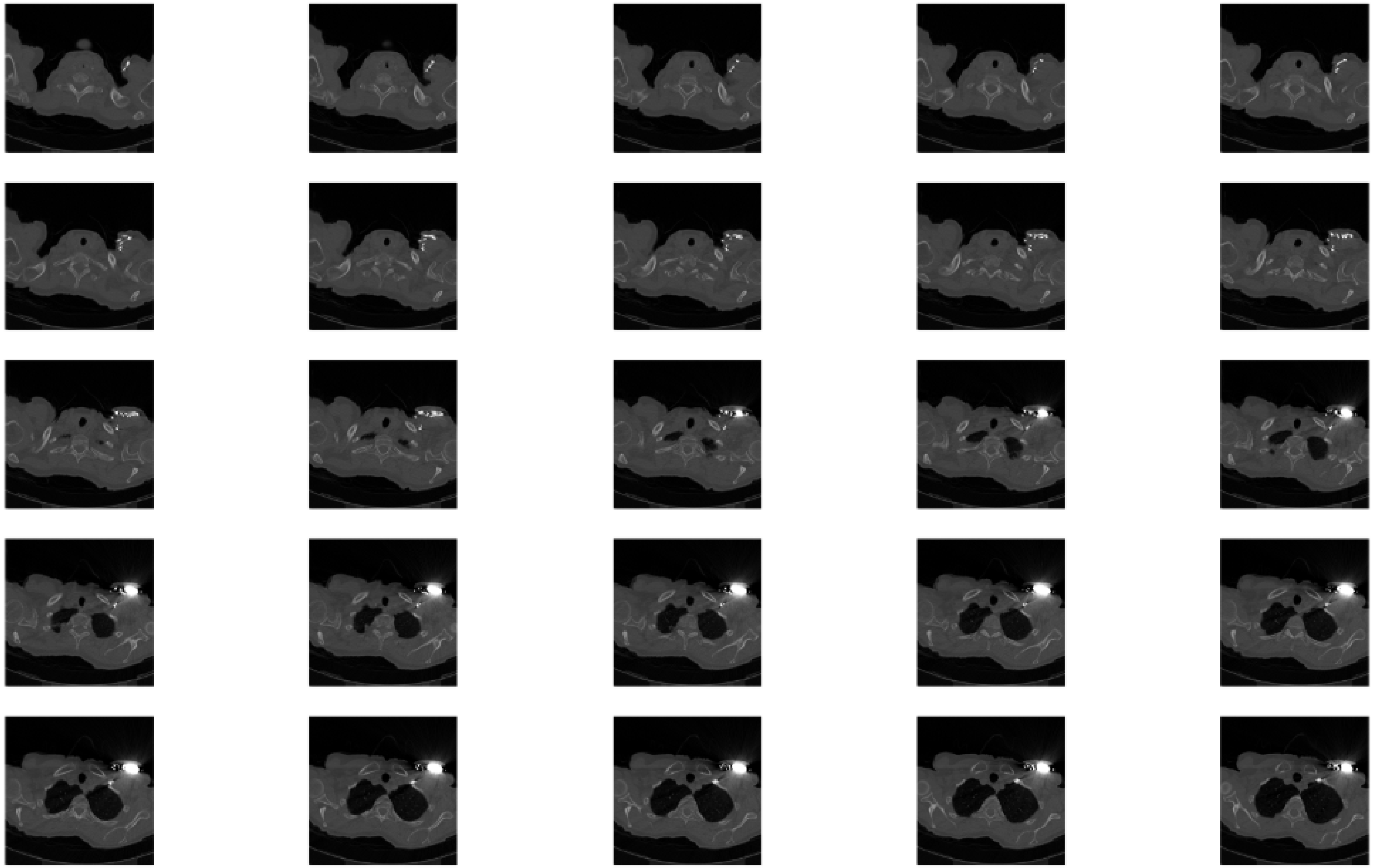
Part 2 (20%)

- In part 1, we read in only one individual slice (a DICOM file). Now we want to read in a 3D volume. (DICOM files in a folder)
- Note that you will need to sort all the slices to make it into correct order. Please explain how do you sort the slices. (10%)
- Normalize all the pixel from Hounsfield Units to float32 type number between 0.0 to 1.0 and display 25 slices in correct order. (10%)

Part 2 (Cont.)



Part 3 (60%)

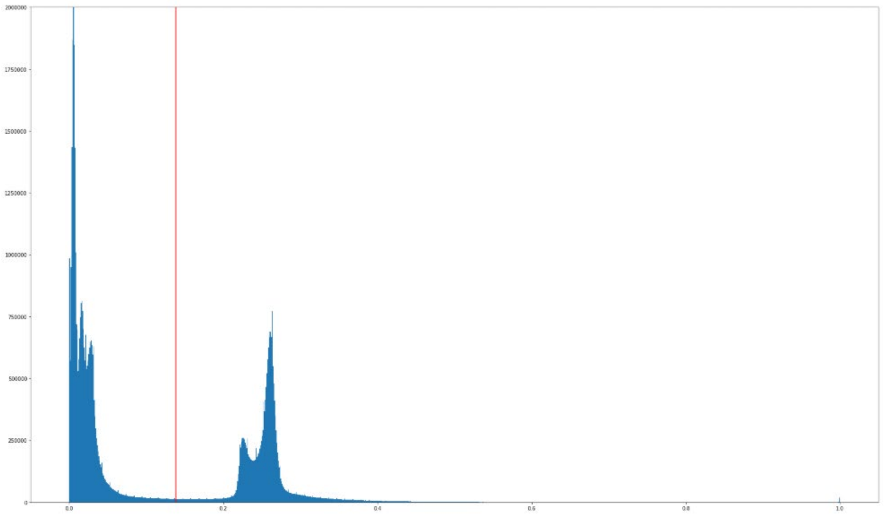
- Now we can try to segment out our lung. We know that lower Hounsfield units correspond to low density materials (like air) and higher Hounsfield units correspond to highly attenuative materials, like bone.
- Please try to use at least two different thresholding algorithm to segment the lung.
- Threshold Value
  - Balanced Histogram Thresholding (BHT)
  - Local mean
  - Local median
  - Otsu's method

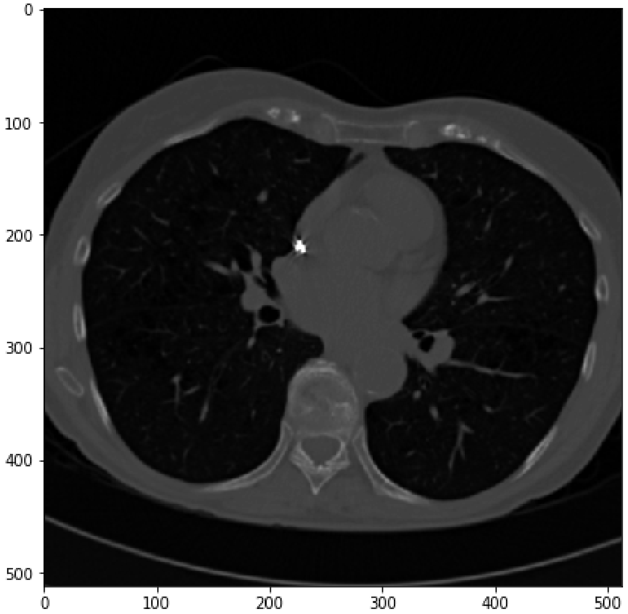
Thresholding Algorithm

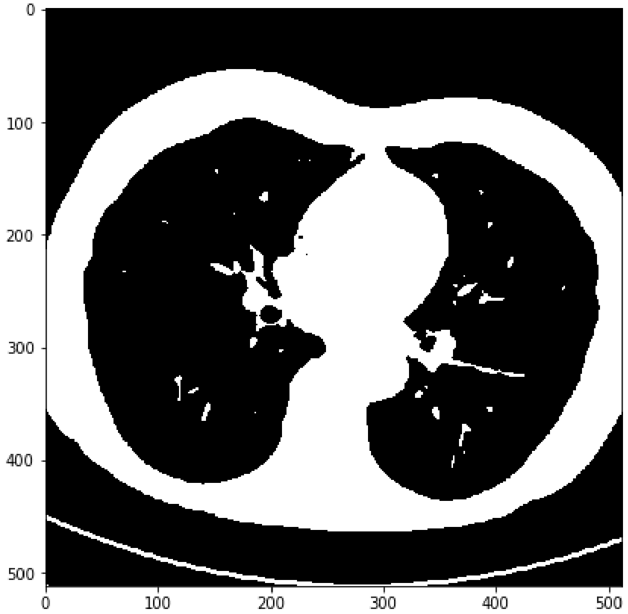
- Choose a threshold pixel value T
- For every pixel
  - if pixel ≥ T, label as foreground
  - else label as background

Part 3 (Cont.)

- Each threshold method: (30%)
  - Plot the histogram of your pixels and the threshold. (15%)
  - Display one CT slice and the corresponded segmentation result. (15%)

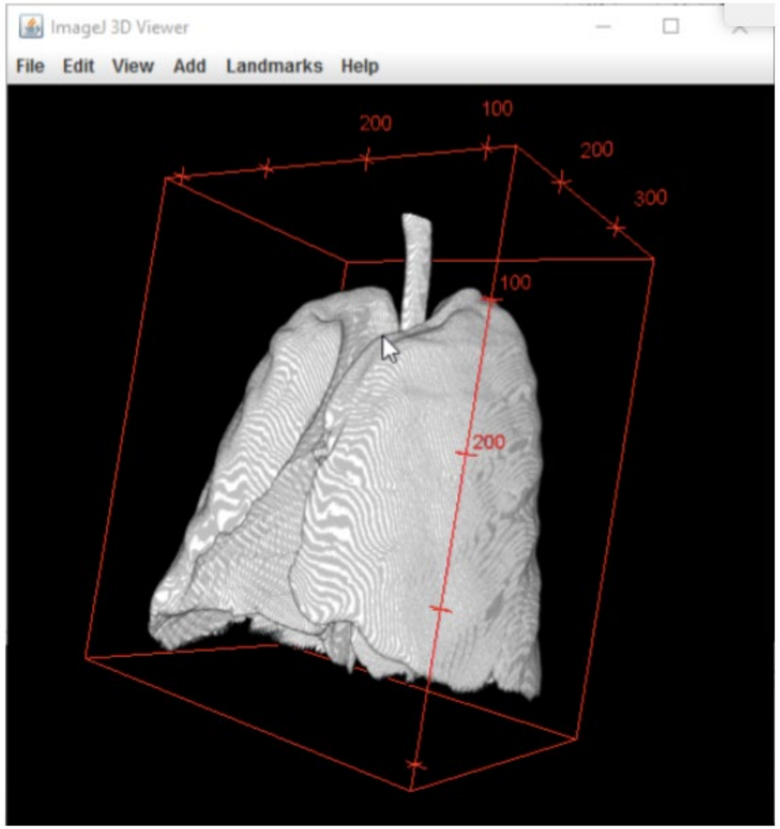






Bonus (10%)

- Try to show your best 3D segmentation result with 3D Viewer.



Environment Requirement and Dataset

- Python 3
- Python package:
  - Numpy
  - Pydicom
  - Matplotlib
  - Skimage
- Please download the dataset from the following link: https://drive.google.com/file/d/1AcO7rZIpSJhPLjgl5ghLxJ0uzqdbBI_w/view?usp=sharing

Report (10%)

- Please write your report with the given latex template in English.
- Show your result inside the report and give some explanations.
- Please also give a short summary about what you have learned.

Reminder

- Please zip your code (.py) and report (.pdf) together and name as {Student_id}_{Name}.zip
- Deadline: Upload to iLMS before 2020/3/29 23:59 (UTC+8).
- Late submission: 20% penalty.
- Wrong hand in format: 10% penalty.
- This is an individual assignment, no cheating.

Hint

- You can write your report through Overleaf, an online latex editor.
- You can write your code with jupyter notebook.