Automatic Segmentation of the Diaphragm within CT Scans using Python

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Introduction

The aim of this project is to fully segment the diaphragm from Computed Tomography (CT) scans.

CT images have low contrast, causing the diaphragm image intensity distribution to be similar to surrounding organs, such as the heart, liver, and spleen[1]. Segmentation of these surrounding organs can help towards the end goal of separating the diaphragm.

DICOM File Format

DICOM (Digital Imaging and Communications in Medicine) is the standard format for medical images and has metadata containing information regarding the patient and the study. Pixel intensities of DICOM images represent the absorption/attenuation coefficient of radiation within a tissue; these intensities are typically analysed as Hounsfield units (HU; Figure 1)[2] .

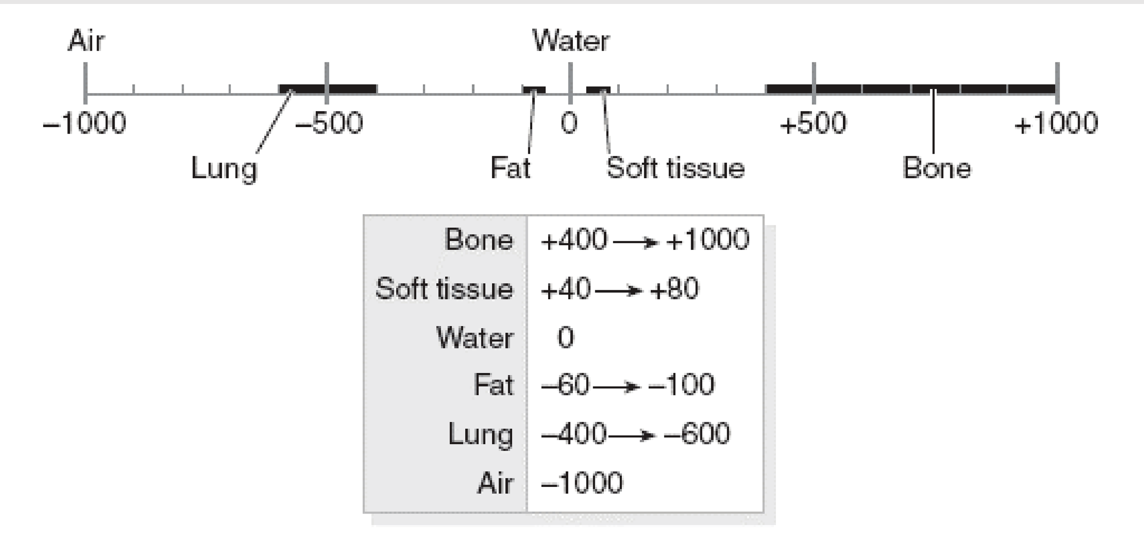

Figure 1. Hounsfield Scale [3]

Key Tools

Python language was used to implement the SimpleITK API for reading DICOM files and applying different methods of segmentation to extract features from the data.

python™ SimpleITK

Approach

Thresholding, connected component filters, image transforms and neighbourhood operation techniques are used for initial segmentation and extraction of the lungs, ribcage (Figure 2, 3) and heart. Diaphragm contact points can then be found, and a B-Spline approximation technique applied to fully extract the diaphragm, as described within Figure 4.

Extraction of the heart and locating diaphragm contact points are the more challenging stages of the approach. Neighbourhood operations were used to label the heart. Diaphragm contact points relied upon applying various techniques for each feature (i.e. canny edge detection).

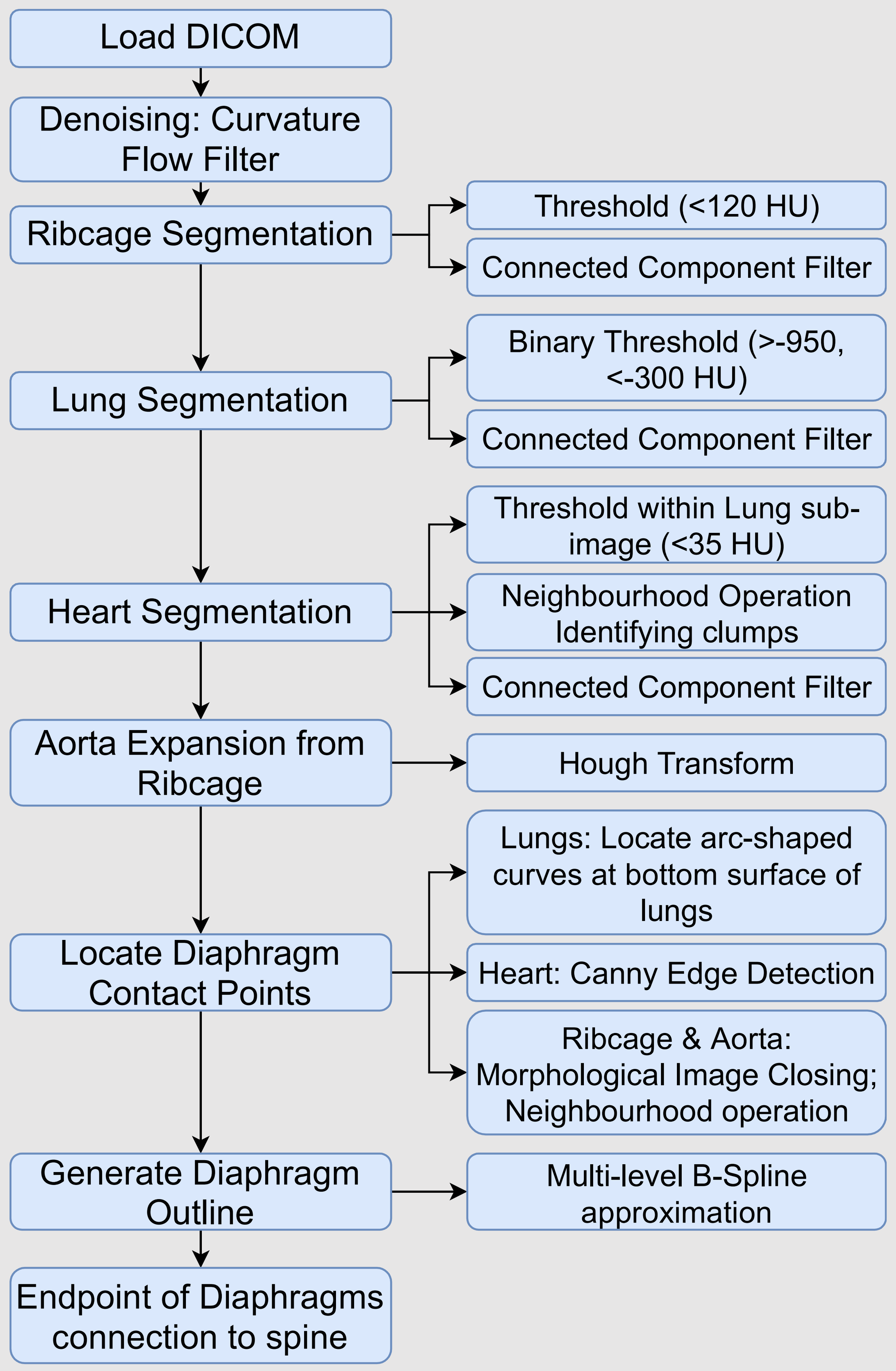

Figure 4. Key stages toward automatic diaphragm extraction from within CT scans and associated approaches.

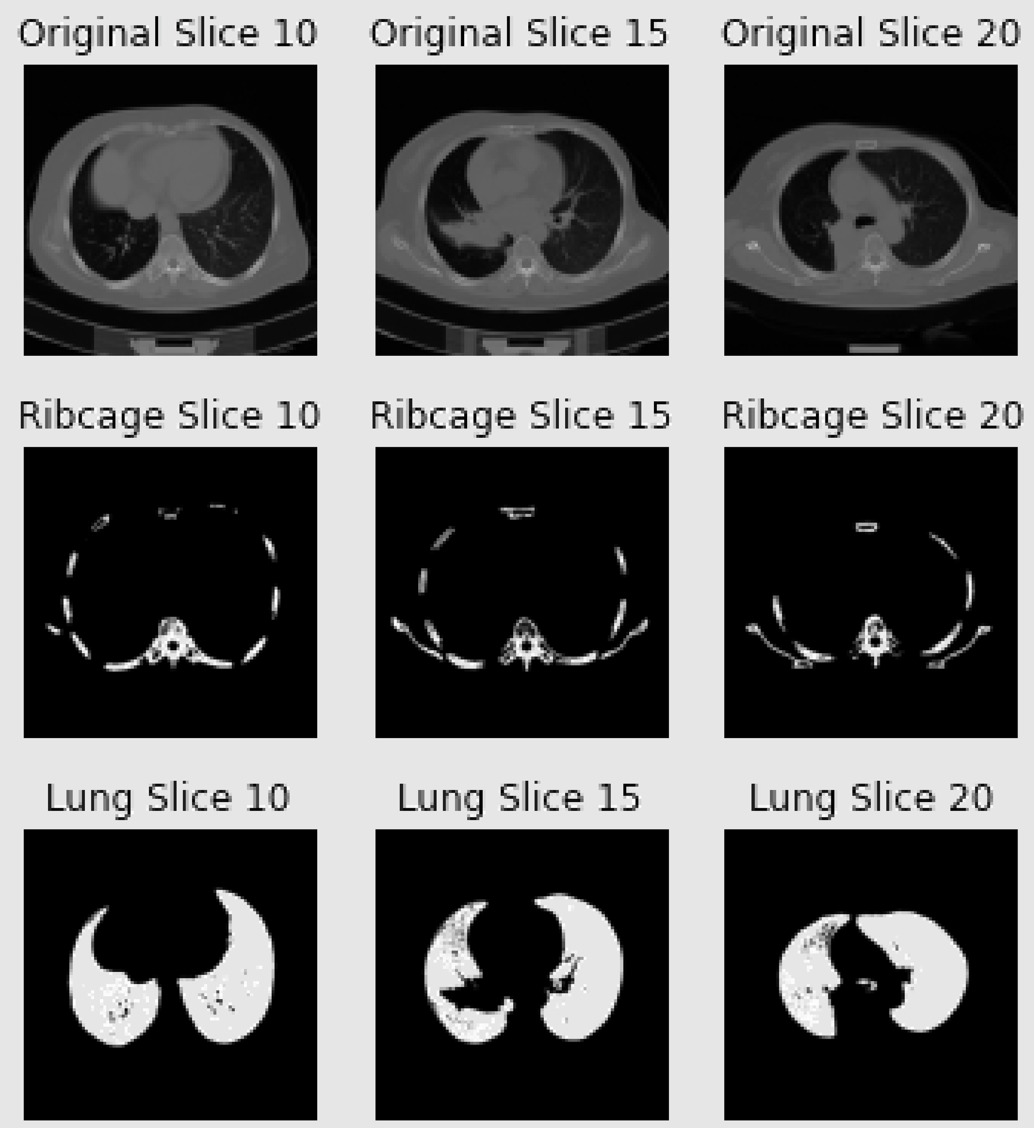

Figure 2. Original CT scan slices (Row 1). Ribcage segmentation (Row 2). Lung segmentation (Row 3).

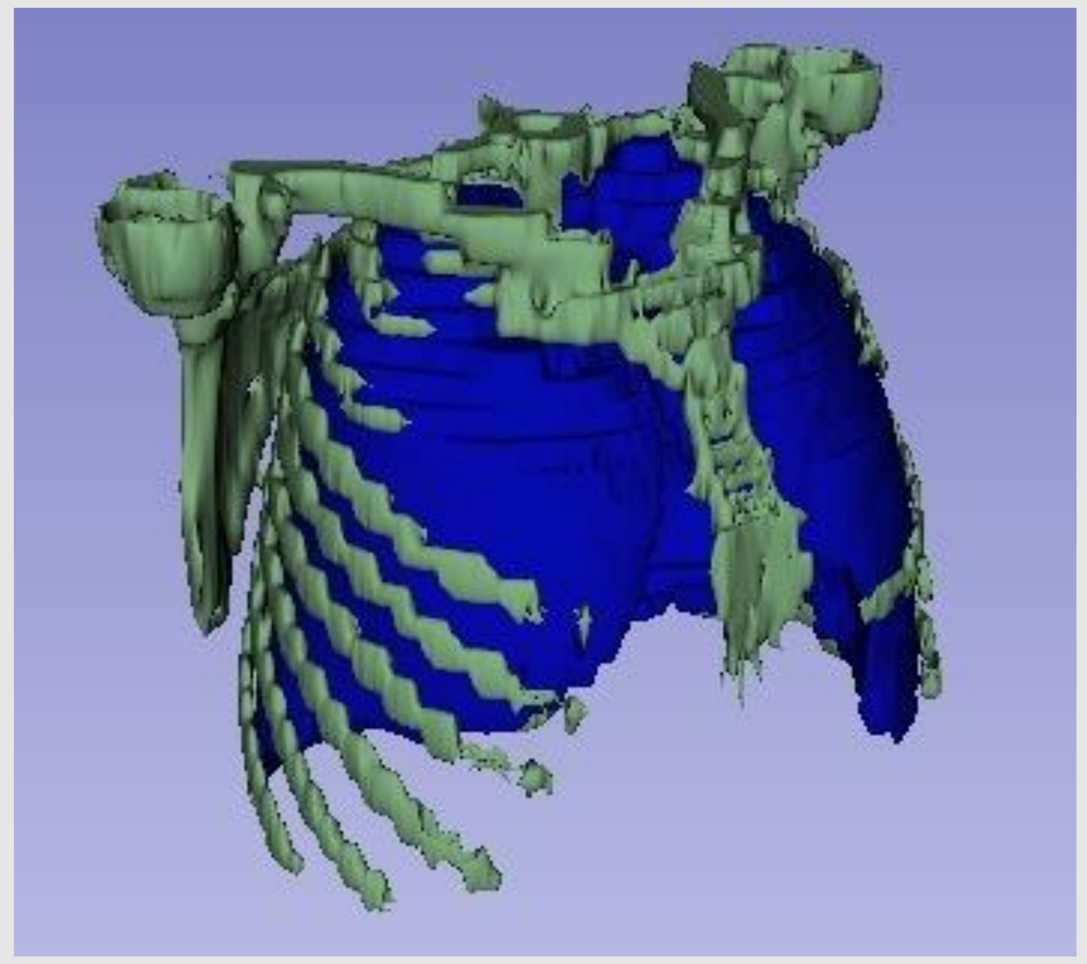

Figure 3. 3D rendering of segmented ribcage & spine (Green) and lungs (Blue).

Results & Future Research

Key Outputs:

- 2D masks & 3D rendering of diaphragms output from approach (Figure 5)
- Stand-alone Python tool for automatically extracting the diaphragm from CT scans

Measuring Success

- Questionnaire & interview from expert
- Comparison against manual annotations

Future Research

Outputs from the work are expected to be relevant to experts developing biomechanical models and understanding of the diaphragm's physiology.

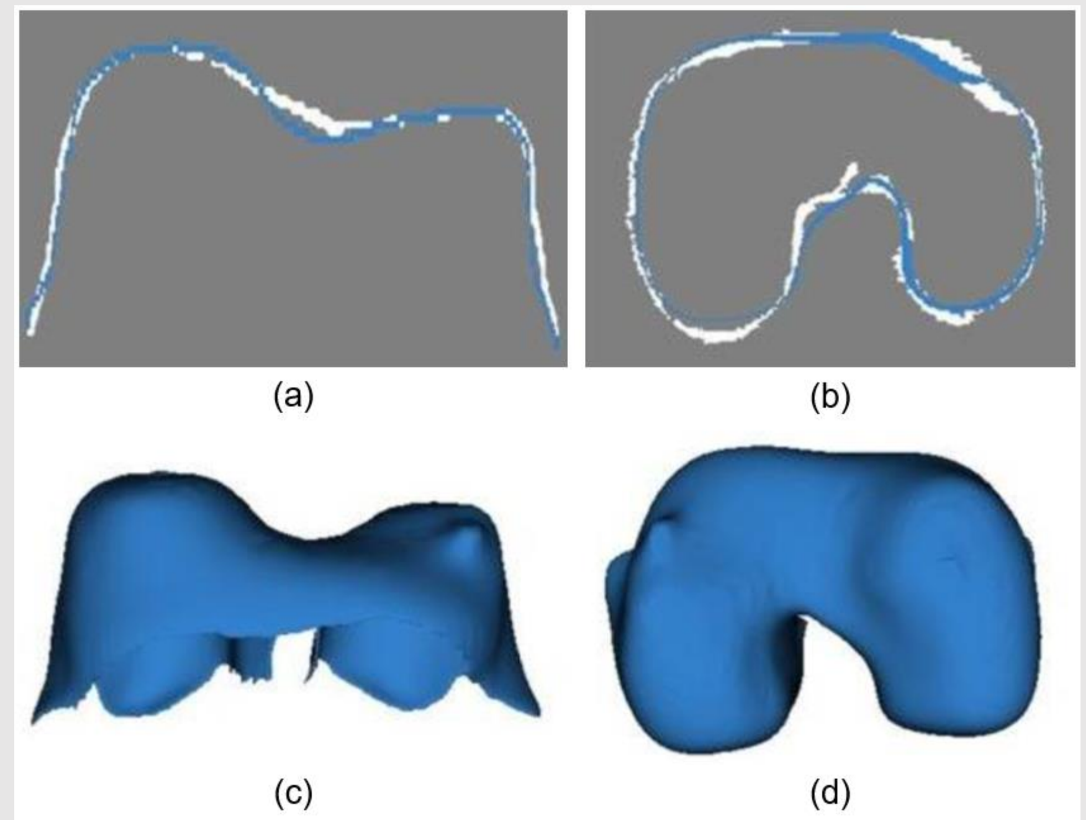

Figure 5. Envisaged final diaphragm segmentation output in 2D CT scan slices (a, b) and rendered in 3D (c, d) [3].

References

[1] Karami E, Wang Y, Gaede S, Lee TY, Samani A. Anatomy-based algorithm for automatic segmentation of human diaphragm in noncontrast computed tomography images.Med Imaging (Bellingham). 2016;3(4):046004. doi:10.1117/1.JMI.3.4.046004

[2] DenOtter TD, Schubert J. Hounsfield Unit. In:StatPearls. Treasure Island (FL): StatPearls Publishing; May 11, 2020.

[3] Elsayed, Omnia & Mahar, Khaled & Kholief, M. & Khater, Hatem. (2015). Automatic detection of the pulmonary nodules from CT images. 742-746. 10.1109/IntelliSys.2015.7361223.