EFFECT OF IMAGING PARAMETERS ON LUNG VESSEL SEGMENTATION FROM CHEST CT SCANS

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I. INTRODUCTION

- Lung vessel quantification has implications in vascular diseases and insults including:
  - Chronic pulmonary arterial hypertension[2,4]
  - Chemotherapy-related lung or tumor injury
  - Altered vascular development in children with extreme pre-term gestation
  - Injury due to radiation or other environment insult [3]
  - Angiogenesis around tumors
- The ability to accurately identify and characterize lung vessels (density and morphology) from a chest CT can be impacted by a variety of factors including voxel size, image reconstruction parameters, patient motion and use of a vascular contrast agent [1,5]

HYPOTHESIS: The effect on captured branch count and size of using different scan parameters (differences in voxel size, slice thickness and reconstruction filter) can be characterized and modelled.

OBJECTIVE: Analyze the effect of using different scan parameters and start to determine the relationships between them.

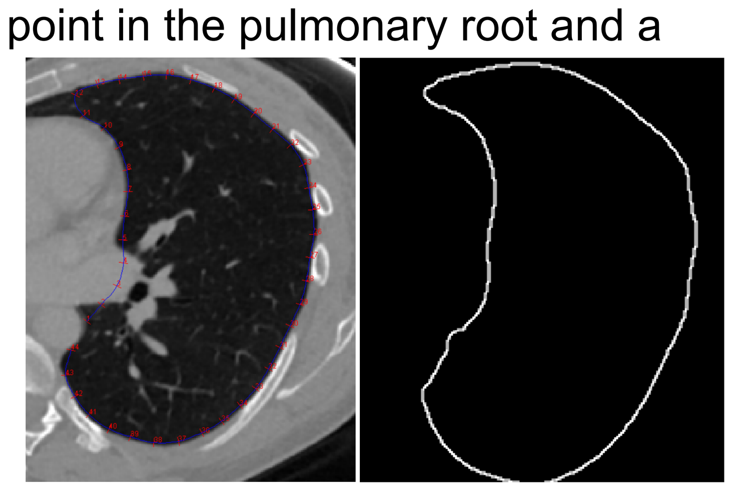
II. IMAGING METHODOLOGY

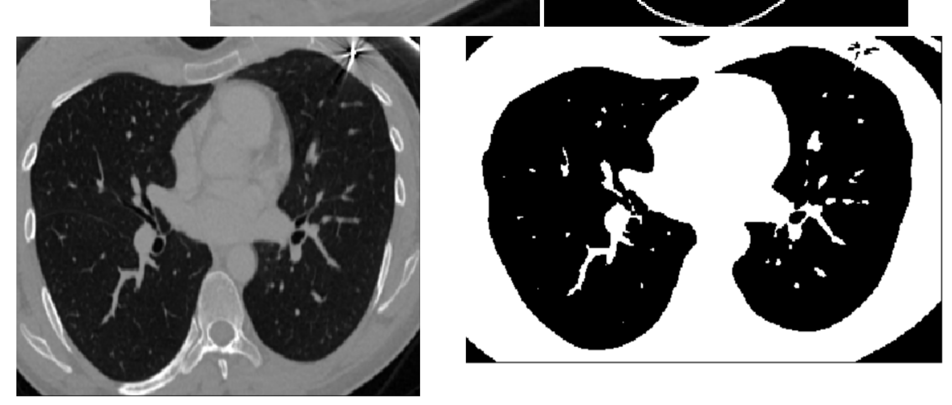
MATERIALS AND METHODS

- A diagnostic-quality representative chest CT scan of a human subject was acquired and the raw data, previously saved on the CT scanner console, was used to reconstruct a set of 16 CT data-sets including
  1. slice thicknesses: 0.5, 1, 2 and 3 mm (no overlap)
  2. isotropic in-plane pixel dimensions: 0.543 and 0.702 mm
  3. with/without a Lung enhancement filter.
- For each of the image sets, the 3D lung vascular system was segmented and characterized semi-automatically via flood-filling starting from a manually-selected seed point in the pulmonary root and a pixel-intensity threshold for distinguishing vessel from background.
- The same seed point and thresholds were used for all runs.
- A radius-histogram for vessel count was tabulated for each data set.

LUNG SEGMENTATION

- Lungs are initially segmented to create a binary image that defines the position of the lung in the CT scan.
- Steps:
  1. Initial lung volume mask generated through a series of thresholds, inversions and 3D flood-fills.
  2. Use active contours (snakes) to trace lung outline and adjust manually when needed (Fig. 1).
  3. Erode snake mask by 2 mm, to remove chest wall pixels.





Figures 1-4: The figures depict the image of lung segmentation for a single slice of the CT scan. The original image is on the left and the binary result image is on the right.

VESSEL SEGMENTATION

- Steps:
  1. Crop to chest. Get lung volume and airway masks.
  2. Choose and apply appropriate minimum vessel and difference thresholds (-560Hu and 500Hu respectively was used)
  3. Select seed and fill vessel using thresholds.
  4. Remove internal holes and fibrosis.
  5. Change outputs to obtain more readable data.

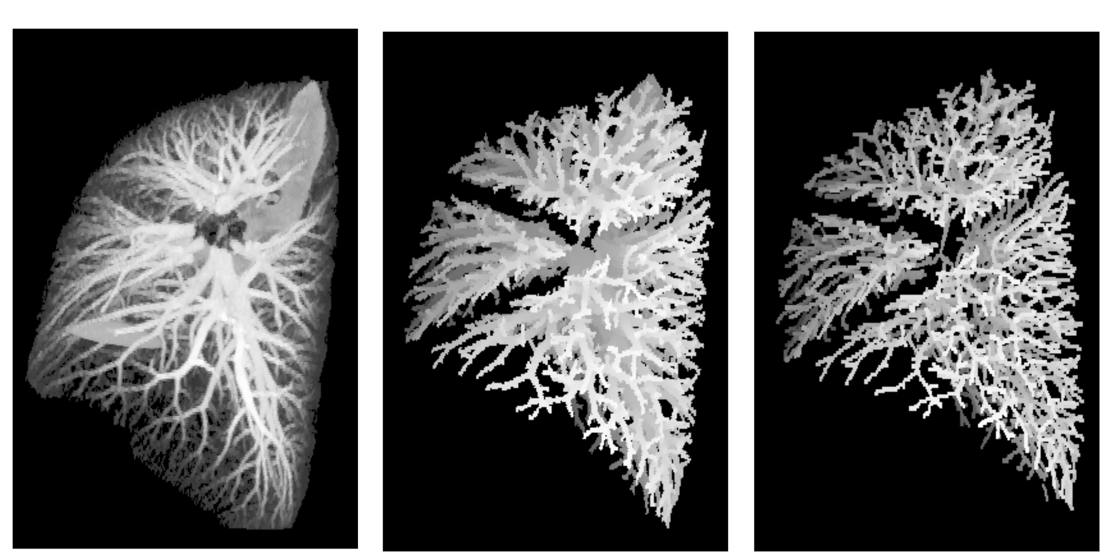


Figure 5-7 shows the visual representation of the vessel segmentation process. The steps are shown in the vessel segmentation section and ultimately allow the vessels to be individually identified and counted.

DATA ANALYSIS

- Data obtained to understand scan parameters and the relationship between them.
- Utility of the model was found.
- A calibration model was formulated as:
  - $N=No(1+ a1s+ a2p+ a3f+ a4s2+ a4sf)$
  - s = slice thickness [mm], p = in-plane pixel size[mm]; f = {0,1} for Body vs. Lung filter.

III. RESULTS

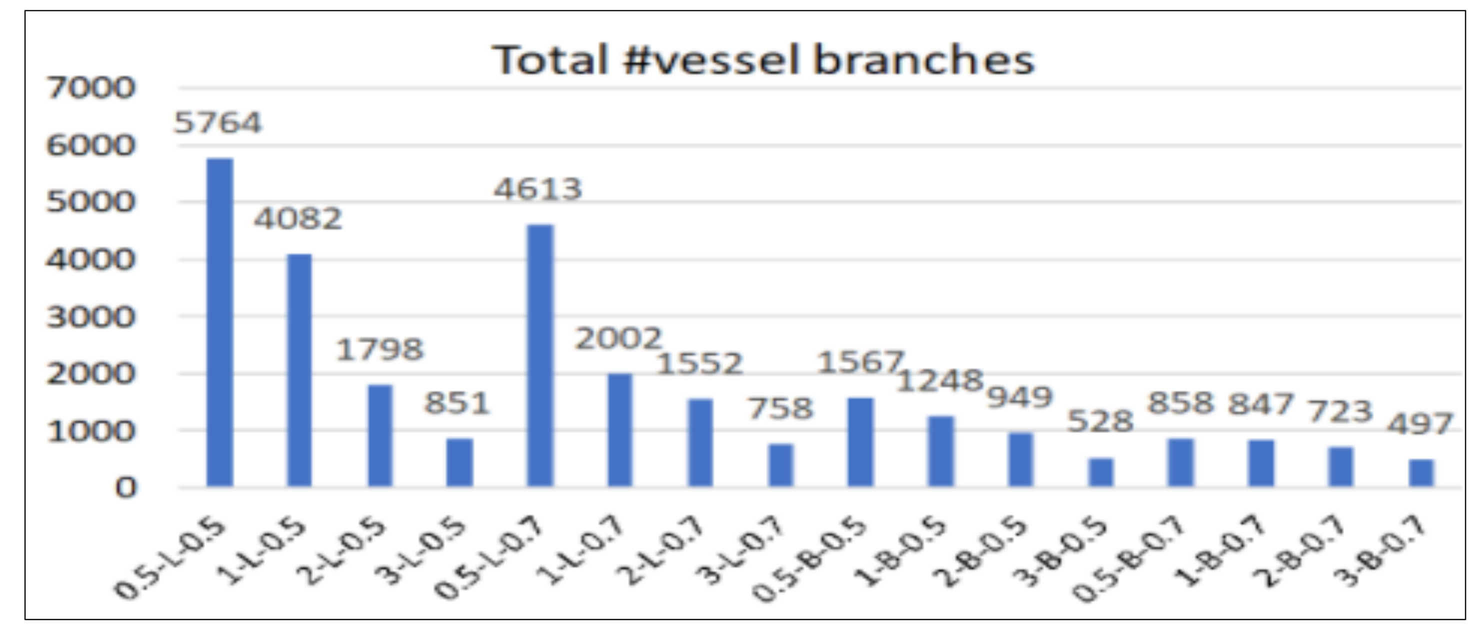


Figure 8: Plot illustrating number of detected vessel branches for 16 different CT reconstruction parameters. Each bar label indicates slice thickness (0.5, 1, 2 or 3mm), whether a Lung vs. Body filter was used (L vs. B), and the in-plane pixel size (0.543 vs. 0.7 mm).

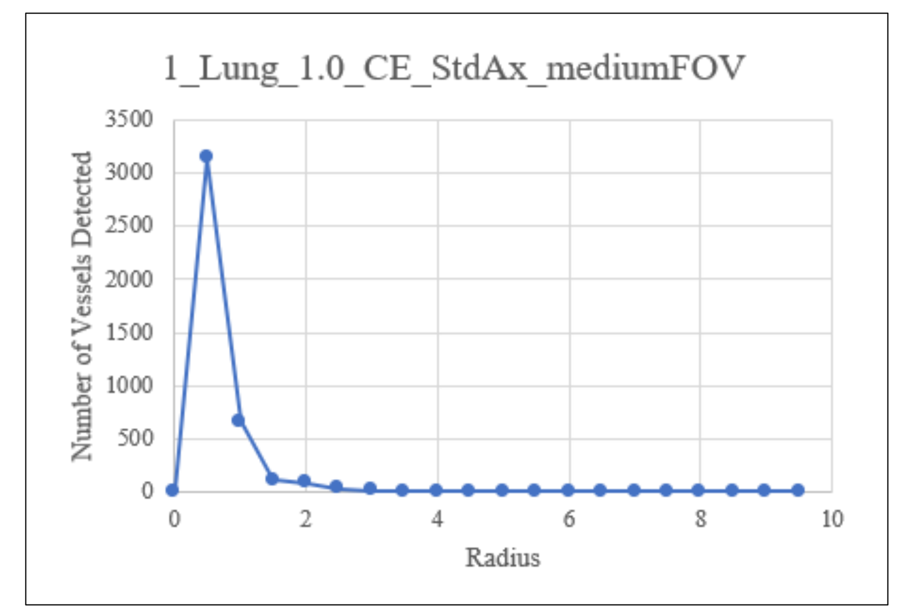


Figure 9: Plot illustrating number of detected vessel branches for the first scan.

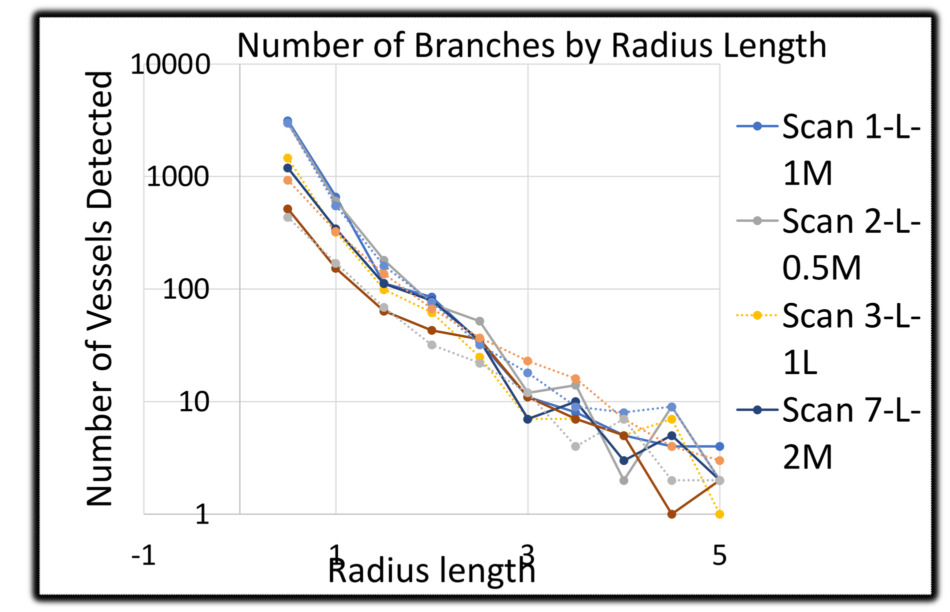


Figure 10: Plot shows multiple scans overlapped to highlight differences between image parameters.

V. CONCLUSIONS AND DISCUSSION POINTS

- Overall, there is a trend towards decreasing vessel branch count with increasing slice thickness and in-plane pixel size; and when using Lung filter vs. Body filter, the former aiding in enhancing the lung contrast-to-noise ratio, thus improving the vessel detection ability. Our model was able to account for 92% of the variance in the response data with adjusted-R2 of 87.5 and p < 0.0001.
- The total number of branches tended to decrease with increasing slice thickness and in-plane pixel size, and when using Body filter vs. Lung enhancement filter.
- . The slice thickness is the most important factor in determining what size vessels can be detected, with the smaller slice thicknesses able to count many more vessels
- Large differences in vessel branch count occur with different scan parameters, thus differences in voxel size, slice thickness, and reconstruction filter need to be addressed for a quantitative comparison of metrics across individuals and over time.
- A simple calibration model fit the data with 92% accuracy.
- More complex models are under development.

V. REFERENCES

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