AUTOMATED SEGMENTATION OF BLOOD VESSELS IN THE PRESENCE OF FIBROSIS IN VOLUMETRIC LUNG CT IMAGES

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INTRODUCTION

Stereotactic radiation therapy for metastatic lung tumors causes extensive radiation damage in adjacent normal lung tissue.

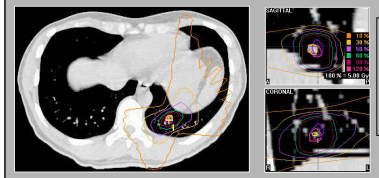


Figure 1: Radiation isodose contours for the treatment of tumor. Hypo-fractionated high doses are delivered in multiple radiation angles such that the tumor gets the lethal dose with little damage to the rest of the organ.

PREVIOUS WORK

Follow-up computed tomography (CT) scans from patients reveal focal regions of fibrosis in irradiated regions with little or no observable damage at distant sites. A non-invasive *in vivo* assay has been developed to estimate radiation damage.

The dose-response relationship is computed through pixel-by-pixel comparison of apparent differences in image intensity (measured in Hounsfeld units) in pre- and post- treatment lung volumes, corresponding to dose values.

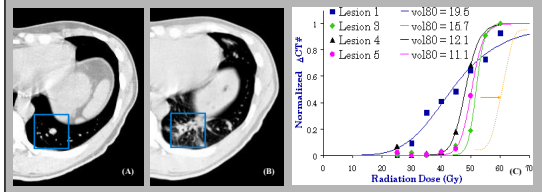


Figure 2: (A) Pre-treatment image slice showing tumor, (B) Post-treatment image slice showing fibrotic tissue, Dose response curves for the 5 treatment sites at 6 months post-treatment. For each site vol_{80} [ml] is the volume of normal lung tissue included in the 80% isodose volumes

PROBLEM

Blood vessels surrounding regions of fibrosis have been observed to contribute to the pixel-by-pixel comparisons owing to their similarity in intensity to fibrotic lung tissue.

AIM

- To automatically segment the blood vessels and adjacent tissue on thoracic CT images
- To iteratively monitor the vessel diameter using Euclidean distance measures
- Create vessel tree mask on the post-treatment images to isolate just the fibrotic tissue

MATERIALS

Phantom Data: CT scans of anthropomorphic thoracic lung phantom and vasculature insert

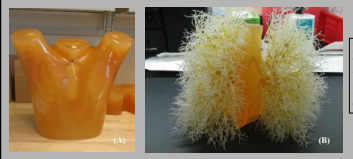
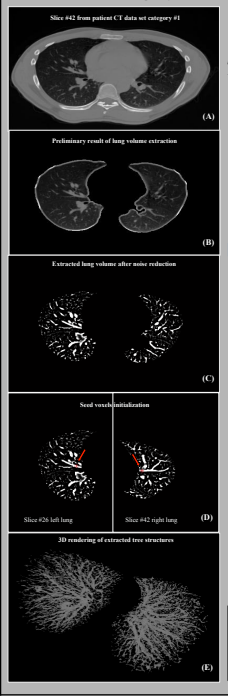


Figure 3: (A) Exterior Shell of Thoracic Platform, and (B) Vasculature Phantom (National Biomedical Imaging Archive, Gavrielides *et al.*)

Patient Data Category 1: Post-treatment follow up CT scans with focal regions of fibrosis

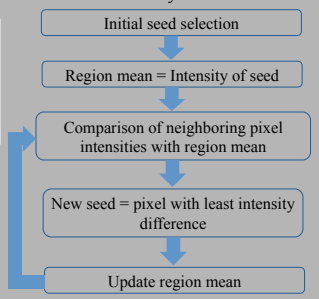
Patient Data Category 2: Pre-treatment CT scans with tumors



METHODS

SEEDED REGION GROWING (SRG)

Neighboring pixels within the same region are similar in intensity



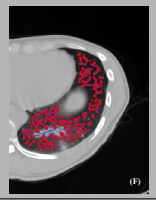


Figure 4: (A)-(F) Snapshots of the various stages of the automated segmentation algorithm applied to a patient with lung fibrosis. The blue lines in (F) show the skeleton of the segmentation result and the red regions correspond to the blood vessels in the region.

RESULTS AND DISCUSSION

Data set #1: Patient dataset with fibrosis

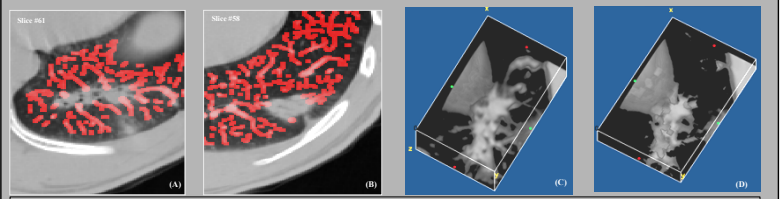


Figure 5: (A)-(B) Results of blood vessel masking near fibrotic tissue at two different slices. Regions colored in red correspond to the vessels that have been masked, (C) 3D rendering of a representative volume from original stack showing fibrosis, and (D) 3D rendering of the fibrotic region after vessels were removed.

Data set #2: Patient dataset with tumors

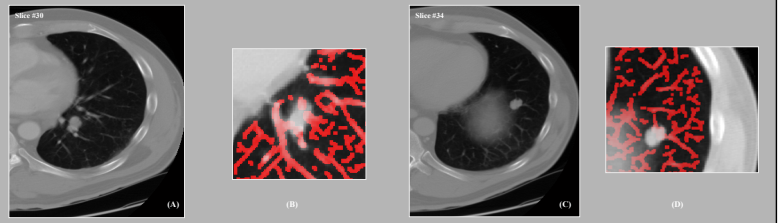


Figure 6: (A)-(D) Results of blood vessel masking near tumors at two different slices. (A) and (C) show slices before the segmentation was performed. (B) and (D) show the results of masking. Regions colored in red correspond to the vessels that have been masked.

The Automated Segmentation Algorithm:

- capable of segmenting blood vessels as small as 2 mm in diameter, starting from two seed points - one for each lung;
- potentially extendable to other imaging modalities (MR images of lung) and organs (e.g liver) by optimizing parameters;
- simple, fast, and robust to noise; and
- can be used in clinical applications to identify and isolate vascular trees in the lung assisting in automated detection and quantification of anomalies in tree structures.

REFERENCES

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