A New Rule-Based Ventral Cavity Multi-Organ Automatic Segmentation in CT Scans

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Abstract

About 68 million CT scans are performed in the USA each year. This huge number of scans does not allow adequate diagnosis and interpretation of each scan, as the time invested for scan reading is only a few minutes. There is an urgent need for novel methods to automatically analyze and quantify different structures in CT scans in order to improve current patient care

We describe a new method for the automatic delineation (segmentation) of multiple organs of the ventral cavity in CT scans. Our method is unique in that it uses the same generic segmentation approach for all organs.

Method

In our generic framework, the segmentation of each organ is performed in four successive steps

1. Definition of the organ's Binary Inclusive Region Of Interest (BI-ROI) based on the target organ intensity values.
2. Identification of the organ's Largest Axial Cross Section Slice (LACSS). This is the CT scan slice where the organ has the largest axial area.
3. Removal of remaining background structures from the LACSS by morphological operations.
4. Organ segmentation by 3D region growing starting from the LACSS inside the BI-ROI

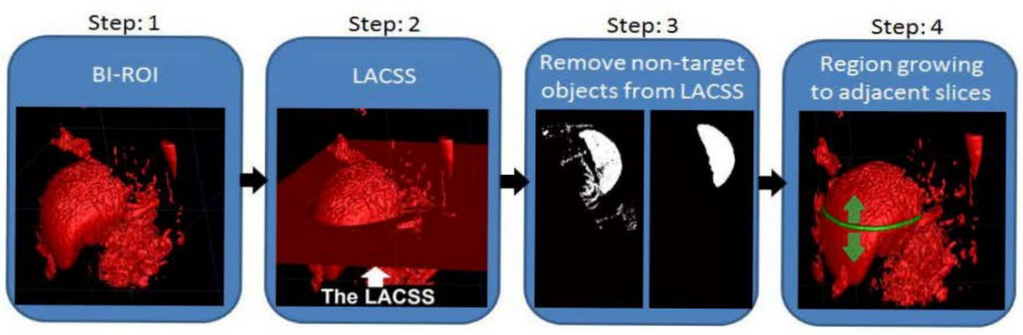
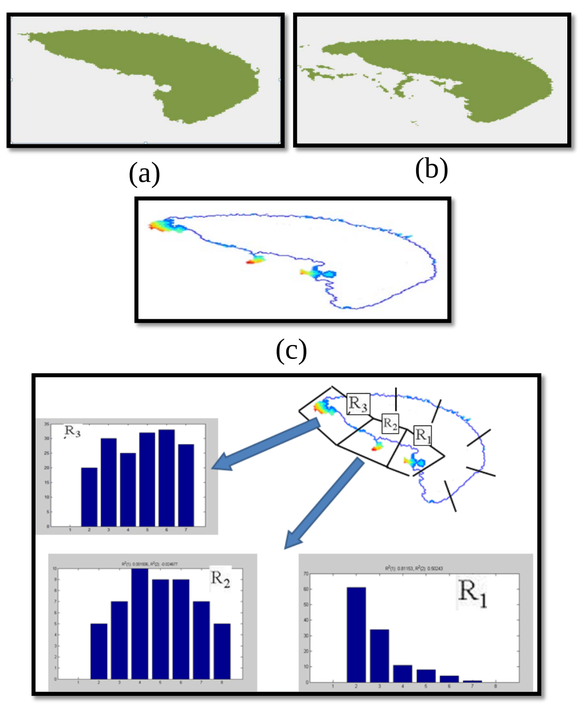


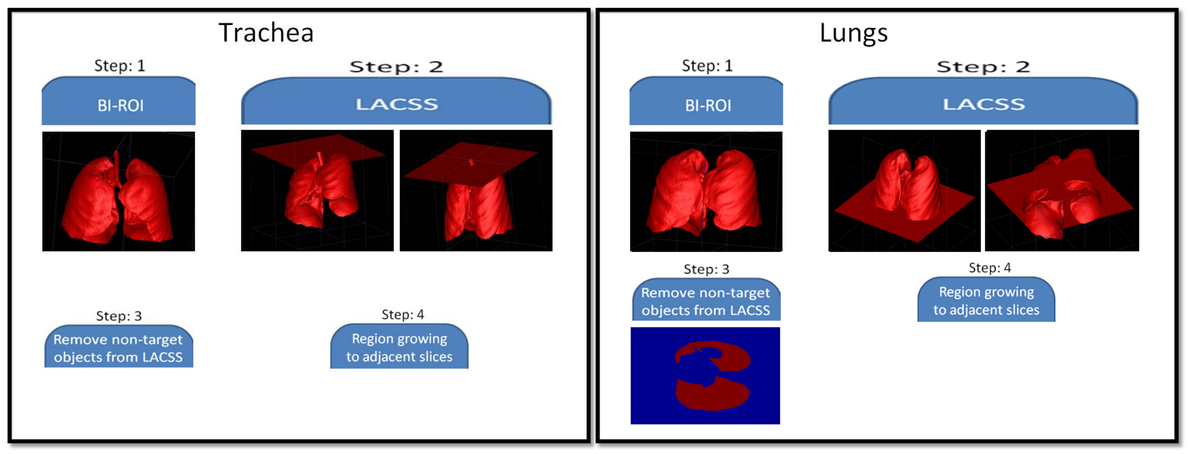
Figure 1: The four steps of the generic organ segmentation framework exemplified on the spleen.

Illustration of step 4:

Distance map between the LACSS contour (a) and the adjacent slice (b) is computed, with the LACSS contour distance set to 0 (c). In the resulting intersection, we define a series of windows along the contour (d) and compute the intensity histogram in each window. Finally, windows whose histograms have a positive kurtosis are considered as segmentation leakage, e.g. windows R1 and R2.

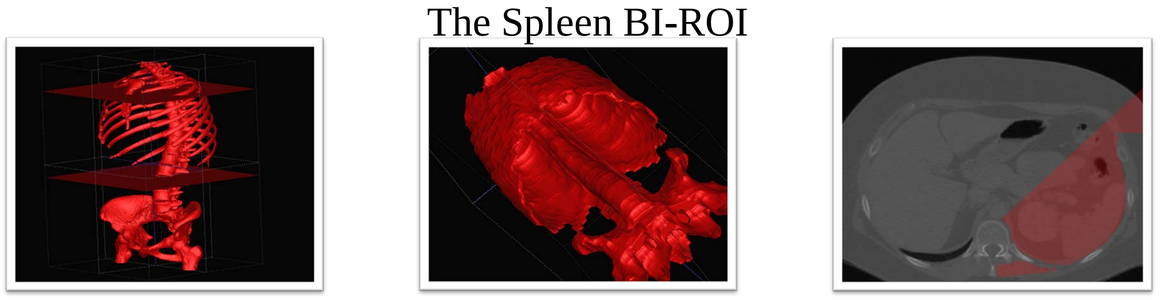


Case study1: Breathing System Segmentation



Case study2: Spleen

The Spleen BI-ROI

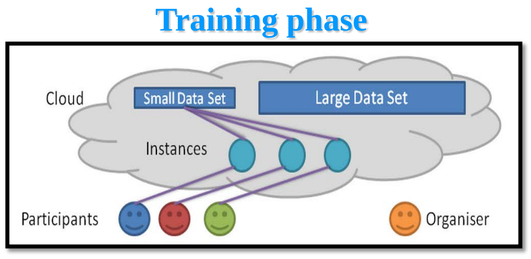


(a) (b) (c)

Evaluation

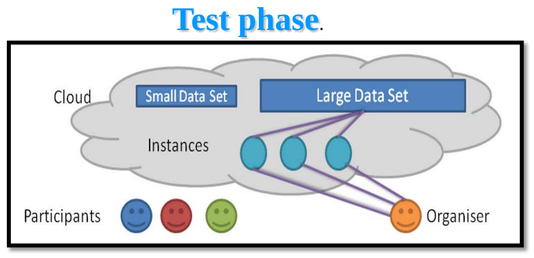
Our system was independently tested by the organizers of the VISCERAL benchmark

Training phase



The participants each have their own virtual machine (VM) in the cloud

Test phase.

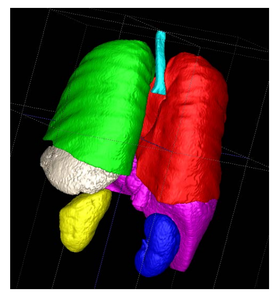


After the deadline, the organizers run the participant executables in their given VMs against the test data

Results

In the VISCERAL benchmark our method yielded an accuracy of more than 92% in and was ranked 1st among other methods that participated in the benchmark.

Training dataset	Left Lung	Right Lung	Trachea	Spleen	Left Kidney
	97.4	97.6	79.1	89.2	92.8
Test dataset	Left Lung	Right Lung	Trachea	Spleen	Left Kidney
	97.9	97.0	85.6	93.4	90.2



Conclusions & Application

The benchmark results prove not only the capabilities of our method, but also its robustness under various scanning environments and users. Our research, therefore, is on the verge of being implemented in clinical environment for real-time purposes.

Implementing our method in hospitals and private clinics would provide the basis for a unique medical imaging search engine. It would highly improve current situation in which doctors are struggling under the burden of diagnosing of CT scan in less than 5 minutes, due to the high number of CT scan acquired in the clinic.