

SALSA – A SIMPLE AUTOMATIC LUNG SEGMENTATION ALGORITHM

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1. ALGORITHM

This section contains a concise description of the algorithm, that is divided into 6 steps.

After the original image is loaded, a simple thresholding operation is performed to discard data that we are confident that do not belong to the lungs (Figure 1a). After the thresholding, we select the outermost boundary voxels in the axial slices of this pre-segmented volume.

The seeds found in Step 1 are then used to perform the Step 2, a boundary growing segmentation algorithm to isolate the respiratory system (Figure 1b). The boundary growing is controlled by the neighbors intensities and Sobel values computed at the center voxel. Then, we flood the outside of the body using a 2D FloodFill algorithm (but not painting voxels belonging to vessels), originating a partial segmented background that is merged with the object made up by voxels next to trachea to complete the background, as can be seen in the red and yellow objects of Figure 1c, respectively.

The Step 3 finds the trachea using anatomical clues, by searching for a tubular structure. Since some images are rotated at the caudal axis, the algorithm has to search for the trachea in both directions (Figure 1d).

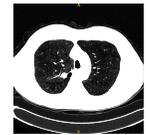
At this point we have segmented all background and trachea voxels and need to segment both lungs, which could be connected. We then use the previous boundary and the result of the application of the Sobel filter to get a detailed border and place a planar cut at the center of the image to avoid possible leaks from one lung to the other, if the lungs are still connected. Using two seeds (one for each lung), we flood the connected voxels creating a partial lung segmentation that is bounded by the planar cut. Afterwards, the voxels close to the cut are analyzed to complement the lungs and optimize the cut volume using a local search (Figure 1e). Several independent cuts can be moved at different directions in each scan since the lungs can be connected at different locations.

Since the vessels were not initially detected as belonging to the lungs or to the boundary in Step 2 (Figure 1b), we add them back into the lung volume in Step 6 (Figure 1f) to re-compose the two lung volumes.

Finally, the final segmentation showing the trachea, left and right lung is assembled, as can be seen in Figure 1g.

1 - Image Thresholding

The original volume is thresholded to discard data that do not belong to the lungs.



(a)

2 - Boundary Detection

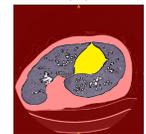
A boundary growing segmentation algorithm is used to isolate the respiratory system.



(b)

3 - Background Removal

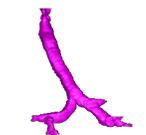
The background volume is produced by combining the trachea (yellow) and the outside of the lungs (red) objects.



(c)

4 - Trachea Segmentation

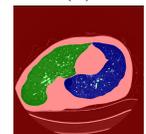
The trachea is found by searching for a tubular structure inside the boundary of Step 2.



(d)

5 - Lungs Segmentation

The lungs are segmented using the boundary of Step 2 and a planar cut optimization.



(e)

6 - Vessel Merging

The remaining voxels outside of the boundary, not affected by the 2D FloodFill, are segmented as Vessels and merged with the lung objects to produce the final result.



(f)

Final Result

The final result produced according to the instructions of the LOLA11 challenge.



(g)

Fig. 1. SALSA Algorithm