Improved Implementation of Otsu's Threshold Selection Method and Active Contours (Snakes)

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1. Lung Segmentation using Multi-Otsu and Active Contours

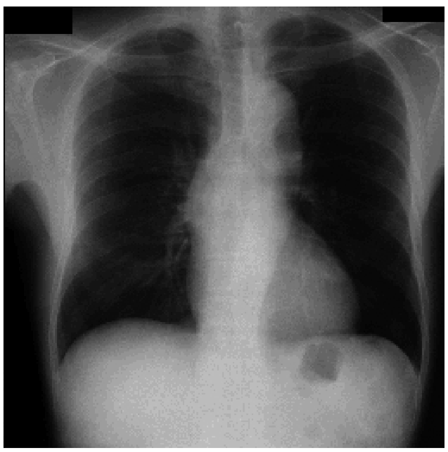

Figure 1. Chest X-ray image used

1.1. Algorithm Overview

- Use multi-level Otsu thresholding to partition the chest X-ray into intensity-based classes.
- Use the resulting low-intensity class as the initial mask for a region-based active-contour segmentation using the Chan–Vese model.
- Perform several iterations of contour evolution to refine lung boundaries and produce a clean binary lung mask.

1.2. Multi-Otsu Thresholding

- Compute the normalized histogram of the grayscale image and treat it as a probability distribution over gray levels.
- Find two thresholds t_1, t_2 that partition intensities into three classes by optimizing the between-class variance

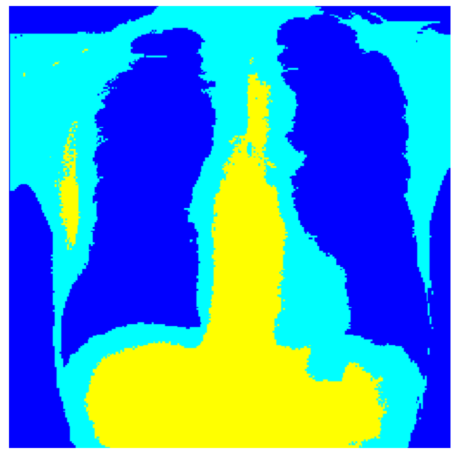

Figure 2. Multi-Otsu segmentation output: three intensity-based regions (air / soft tissue / bone).

— that is, maximising

$$\sigma_b^2 = \omega_0\omega_1(\mu_0 - \mu_1)^2$$

(where ω_i are class probabilities and μ_i their means).

- Assign each pixel a class label via quantization:

$$\text{label}(x, y) = \begin{cases} 1, & I(x,y) \leq t_1, \\ 2, & t_1 < I(x,y) \leq t_2, \\ 3, & I(x,y) > t_2. \end{cases}$$

- Class 1 often corresponds to lung air (dark), class 2 to soft tissue (heart/mediastinum), and class 3 to bone or diaphragm shadows (bright).

1.3. Active Contour (Chan{Vese) Refinement

- Initialize binary mask M_0 using the Multi-Otsu class corresponding to lung air (class 1).
- Apply the Chan–Vese model to evolve a contour that partitions the image into two phases: inside (lung fields) and outside (rest), as shown in figure 4

- Use MATLAB's 'activecontour(..., 'Chan-Vese', nIterations)' (or Image Segmenter app) to perform 170 iterations of evolution.

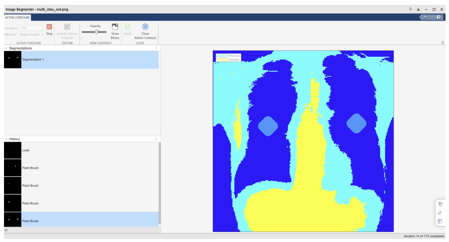

Figure 3. Active Contour refinement applied over the Multi-Otsu mask; the contour evolves to better fit lung boundaries.

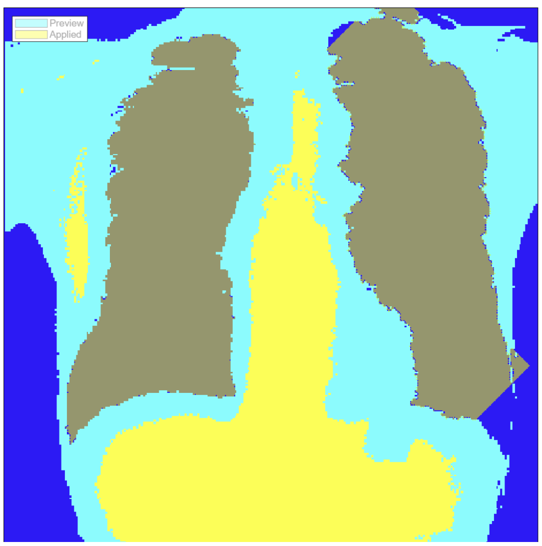

Figure 4. Segmentation by Active-contour (snakes)

1.4. Final Lung Mask

- After convergence, produce a binary lung mask indicating left and right lung fields, as shown in figure 5
- Optionally apply morphological cleanup to remove small holes or spurious artifacts.

1.5. Algorithm Notes

- Multi-Otsu thresholding is histogram-based; it automatically selects thresholds but ignores spatial context, hence segmentation is coarse.
- The Chan–Vese active-contour model does not rely on edge gradients — instead it fits piecewise constant intensity models inside and outside the evolving contour, making it suitable for images with weak or noisy boundaries.

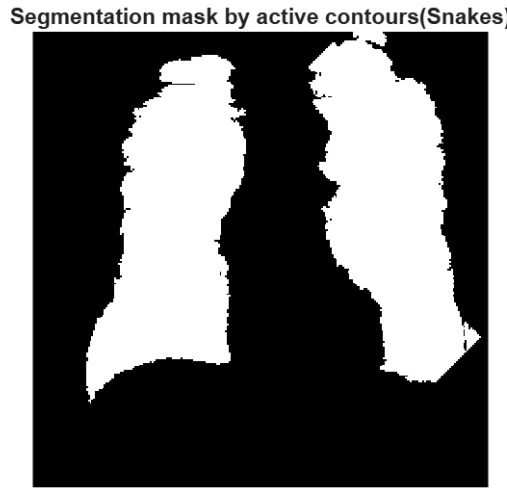

Figure 5. Final binary segmentation mask of lungs after active-contour refinement.

- Combined, the hybrid approach offers a balance between fast global partitioning and local boundary refinement — useful as a classical baseline before deep-learning segmentation.