# Segmentation of Lungs from Chest Radiographs using Boundary Maps and Snake Segmentation Algorithm

**Jangam Ebenezer, Maridu Bhargavi, Syed Shareefunnisa**

***ABSTRACT--- Segmentation of lungs from chest radiographs (CXRs) is an essential pre-processing step performed for disease detection. Numerous techniques were proposed by the researchers to segment lung regions from the chest x-rays. In the past three years, hybrid techniques and deep learning-based techniques were proposed to increase the accuracy of segmentation. In this paper a hybrid method is proposed and evaluated for segmentation of lungs using chan vese snake segmentation method and boundary maps. The proposed method is evaluated using the public JSRT database and Jaccard index of our method is 95.2%, which can be compared to those of other best in class strategies (95.7%). The calculation time of our technique is under 13 s for a 256 × 256 CXR when executed on a standard computer.***

***Keywords: boundary detection, chest radiograph, chan-vese, lung field segmentation, snake segmentation***

## I. INTRODUCTION

Segmentation of lungs is the essential step in the Computer Aided Detection(CADe) and Computer Aided Diagnosis(CADx) of chest x-rays. It is the basic step performed in the automatic tuberculosis screening. It is the part of automatic pneumonia screening. It is used as the first step to detect cardiomegaly (enlargement of heart). It is the preliminary step in lung nodule detection from chest x-rays using computer algorithms. To find out the abnormalities in the lungs from chest x-rays, the primary task is to deliniate the lungs from the chest x-rays.

Researchers proposed a wide range of techniques for automatic lung segmentation, rotation and foreign object detection. Some of the techniques used for lung segmentation are thresholding, region growing, neural networks, active contours, pixel classification, structured edge detection, adversial networks, graph cuts, game theory.

Among the proposed methods, thresholding is the simplest technique. Using this method, a threshold value is selected based on some criteria. The threshold is used to convert the given image into a binary image. A simpler method is to select the threshold using histogram equalization. However, the simple thresholding methods could not give accurate lung boundaries.

Although there are a variety of existing techniques for lung segmentation, researchers are investigating for the novel techniques. This is because the automatic chest x-ray analysis needs highly accurate techniques. Higher the accuracy in segmentation of the lungs, higher is the accuracy in classification and detection of diseases like cardiomegaly, pneumonia and other lung related diseases. In recent times, hybrid techniques are being investigated to improve the accuracy of segmentation of lungs.

Contrasted with traditional component extraction methods, snakes have numerous points of interest, and there are two noteworthy methodologies in image segmentation: edge-and locale based. Edge based Segmentation. Active contour model or snake model was proposed to accurately outline the boundaries of an object.

Dimitris K. Iakovidis et al [1], presented an approach for segmentation of the lung fields in chest radiographs. The proposed method includes recognition of objects on the anatomical structures around the lung fields using Bezier curves. They proposed a method which can naturally approximate the boundaries of the lungs in the chest radiographs

Chengdu, Sichuan, et al [2] proposed a method of detecting the lung regions in chest radiographs. The method assumes that the lung regions differs from the background region considerably.

Bulat Ibragimov et al [3], evaluated using public dataset and the performance is measured as 1.43 ± 0.85 mm boundary-to-boundary distance and 95.3 ± 2.0% area overlap coefficient.

Yeqin Shaoet a [4], proposed segmentation method using points of interest and spatial connections. Candemir et al [7] used SIFT based approach for the segmentation of lungs. Yoshinori itai et al [12], proposed another segmentation technique for the segmentation of lung area by using SNAKES method without considering any manual operations. Y. Y. WONG et al [13], demonstrated that the active contour model, called a snake, has been proved to be an effective method in contour detection.

The paper is organised as follows. Section 2 contains the details of the proposed method which is a hybrid method using boundary maps and snakes (active contours). Section 3 presents the experiment details like datasets used, metrics used, and the results obtained. The next section concludes the paper.

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## II. PROPOSED METHOD

The basic objective of the proposed hybrid method is to extract lung regions from the chest radiograph with high accuracy. The outline of the proposed method is as follows:

1. Take CXR image and apply pre-processing techniques to remove noise and to smoothen the image.
2. Extract the boundary map using Structured Edge Detector (SED).
3. Perform edge detection using Chan-Vese snake segmentation model which is initialized with the boundary map obtained in the previous step.
4. Use morphological operations (erosion and dilation) to estimate each pixel in the resulting image based on the contrasting pixel in original image and its neighbours. Dilation and Erosion are used to improve the accuracy of the segmentation.

### *2.1. Boundary Map*

A boundary map is extracted from the given CXR using Structured Edge Detector (SED). Boundary map for the chest x-ray is estimated using the method in [21] and the outline of the method is as follows

ALGORITHM for Boundary Map detection

Input: Chest X-ray C, SED model and its parametres

Output: Boundary Map B

1: Split CXR into base layer $L_b$ and detail layer $L_d$

2: Sample enough patches $\{p_i\}$ of size 32×32×2 from $L_b$ and $L_d$.

3: Consider each patch at position $(r_i, c_i)$ and perform step 4 and step 5.

4: Calculate and store the indices of trees $\{k=mod(mod(r_i+c_i\ ,\ 2\times T_{eval})+t,\ T),\ t=0, 1, 2, ..., T_{eval}-1\}$.

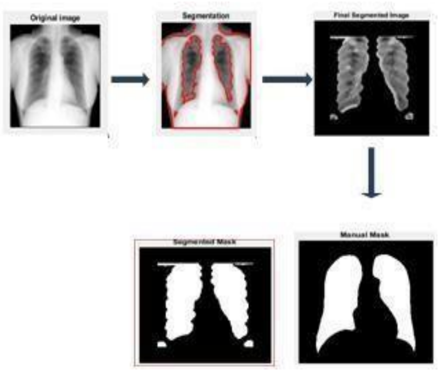
5: Consider subset {k} of decision trees in the trained SED model to the patch pi and estimate the respective boundary patch bi.

6: Collect the overlapped patches {bi} and calculate the mean to estimate the soft boundary map B.

### *2.2. Chan Vese Model*

*The boundary map obtained is used to initialize the snake. Chan-Vese model for active contours is an intense and adaptable strategy which can fragment numerous kinds of images, including some that would be very hard to segment using thresholding or region-based techniques*

A snake is an energy minimizing, deformable spline affected by image energy that draws the spline to twist and internal powers that oppose twisting.




A snake comprises of a set of *n* points whose position is represented by v(s). Snake always tries to minimize the energy $E_{snake}$ which is sum of internal energy $E_{int}$, image forces $E_{image}$ and external constraints $E_{con}$.

$E_{int}$ represents energy due to bending and it ensures that the curve is piecewise smooth. $E_{image}$ represents the energy due to image forces, which push the snake towards the image features like edges etc.

$E_{con}$ represents the external constraints which places the snake at local minimum

Energy of a snake is calculated as the sum of Internal energy $E_{int,}$

Image Energy $E_{image}$ and external constraints $E_{con}$.

$$E_{snake} = \int [E_{int} v(s) + E_{image} v(s) + E_{con} v(s)] ds$$

where v(s) is the position of snake given by (x(s), y(s)).

### *2.3. Erosion and Dilation*

Erosion and dilation are applied to the snake obtained and the operations are repeated in order to obtain segmented lung masks with higher accuracy.

## III. EXPERIMENTAL RESULTS

### *3.1. Performance metrics*

The Jaccard similarity coefficient Ω and Dice coefficient are the commonly used metrics to measure the performance of a segmentation technique.

Jaccard coefficient gives the overlap between Ground truth and segmented image. This can be calculated using the following equation

$$\boldsymbol{\Omega} = \boldsymbol{Tp} / (\boldsymbol{Fp} + \boldsymbol{Tp} + \boldsymbol{Fn})$$

Dice coefficient is another metric used to compare the performance of segmentation techniques.

$$\boldsymbol{Dsc} = \boldsymbol{2Tp} / (\boldsymbol{2Tp} + \boldsymbol{Fp} + \boldsymbol{Fn})$$

where TP (true positives) is the count of pixels which are classified correctly, FP (false positives) is the count of pixels which are identified as part of the object but they belong to background in reality, and FN (false negatives) are the pixels which are classified as background but the fact is that they belong to the object.

### *3.2. Dataset and performance comparison*

JSRT dataset was proposed in order to promote comparison of techniques proposed for segmentation of lung fields, the heart and the clavicles in PA chest radiographs [6]. The images are taken from JSRT dataset, and the borders of both lungs, the heart, and both the clavicles were manually outlined in the CXR images.

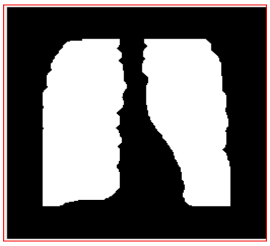
JSRT SCR dataset is the most common dataset used in studies related to segmentation of anatomic structures (lungs, heart, clavicles).

Using proposed technique, lung region is extracted from all the images in JSRT SCR dataset. Average values are computed. The results are compared with the other lung segmentation techniques in

Table 1. Our proposed segmentation technique has recorded an overlap of 95.2±1.6 and DSC of 97.5±1.0 which is better than human observer.

Human observer accuracy is calculated as 94.6± 1.8 and more than half of the segmentation techniques genarated an accuracy more than human observer. The proposed method takes more time when compared to other segmentation technique [21] but it gives a better accuracy.

**Ω=0.9716**



**Ω = 0.9720**

**Fig.2: Examples of lung field segmentation results by proposed method on the JSRT data set**

| Method | Ω | DSC | time |
|---|---|---|---|
| Proposed method | 95.2±1.6 | 97.5±1.0 | <13 |
| SEDUCM[21] | 95.18±1.8 | 97.4±1.2 | <0.14 |
| SIFT-Flow [22] | 95.4±1.5 | 96.7±0.8 | 20~25 |
| MISCP [23] | 95.1±1.8 | / | 13~28 |
| Hybrid voting[24] | 94.9±2.0 | / | >34 |
| Local SSC [25] | 94.6±1.9 | 97.2±1.0 | 35.2 |
| Human observer[24] | 94.6±1.8 | / | / |
| Inverted Net [26] | 94.6 | 97.2 | 7.1 |
| Post-processed[24] | 94.5±2.2 | / | 30 |
| ASM tuned [24] | 92.7±3.2 | / | 1 |
| ASM _SIFT [24] | 92.0±3.1 | / | 75 |

**Table 1: Comparison of performance of proposed method with existing segmentation methods**

## IV. CONCLUSION

Using Boundary map for initialization of parameters in Snake segmentation yeilded an average overlap is 95.2 for JSRT dataset, which is on par with the state of art segmentation techniques. Optimization techniques can be applied to improve the results further as a future work. Investigation is needed to compare the performance of different lung segmentation techniques with datasets of different sizes.

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