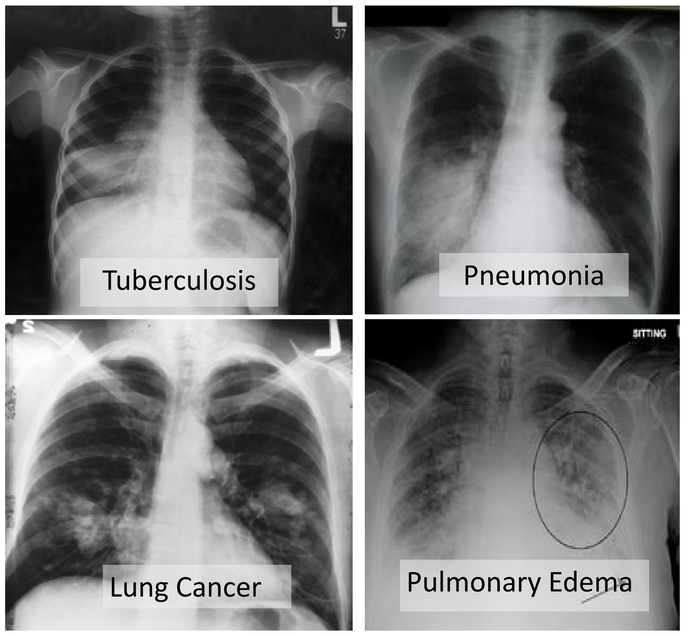
A Combined Approach for Lung Boundary Segmentation of Chest X-ray Images

Sema Candemir, Stefan Jaeger, Alexandros Karargyris, Zhiyun Xue, Sameer Antani, Rodney Long, George Thoma, and Clement McDonald

Lister Hill National Center for Biomedical Communications, U.S. National Library of Medicine, National Institutes of Health

Motivation

The National Library of Medicine, in collaboration with Indiana University School of Medicine, AMPATH (an organization providing HIV/AIDS treatment in Kenya), is developing a computer-aided system for screening and detecting the pulmonary pathologies in chest radiographs.



One of the first step of this system is the automatic detection of lung regions.

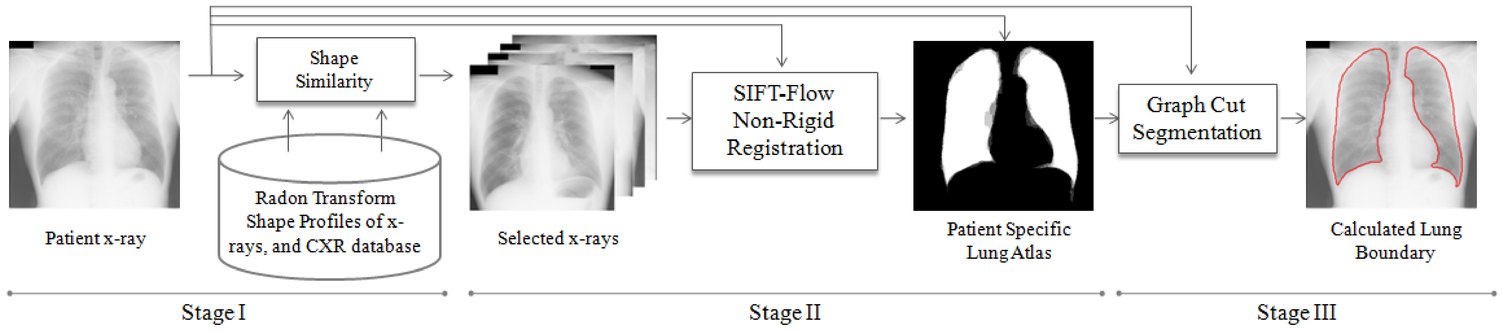
System Overview

The system has three main stages

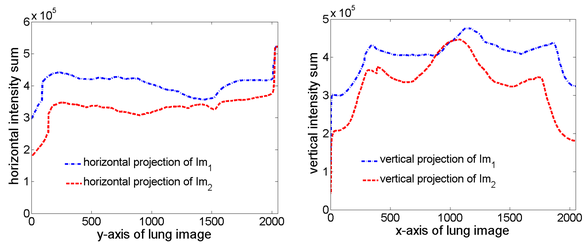
(i) Identifying training atlases most similar to the patient x-ray using a shape similarity measure.

(ii) Creating the initial patient-specific anatomical model of lung shape using a deformable registration approach.

(iii) Extracting refined lung boundaries using a graph-cuts optimization approach with a customized energy function.

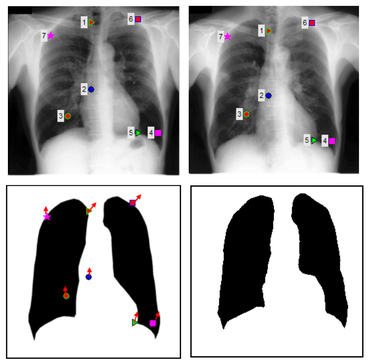


Stage – I Lung Shape Similarity



The similarity between the projection profiles between the atlas in the database and the patient x-ray is measured using Bhattacharyya coefficient.

Stage – II Registration



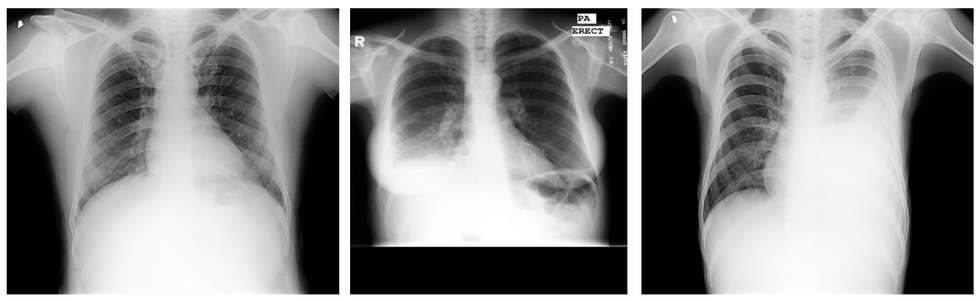
Stage – III Segmentation

Desired segmentation criteria:

- The segmentation labels should be consistent with the image intensities,
- The neighborhood labels should be consistent with each other,
- The segmentation should fit the calculated shape model.

$$E(f) = \alpha_1 E_d(f) + \alpha_2 E_s(f) + \alpha_3 E_m(f),$$

Challenges at Lung boundary detection



- Strong edges at rib cage and clavicle region
- Intensity variation at clavicle region
- Sharp corner at costrophenic angle
- Anatomical shape variations due to varying heart dimensions.

Acknowledgment

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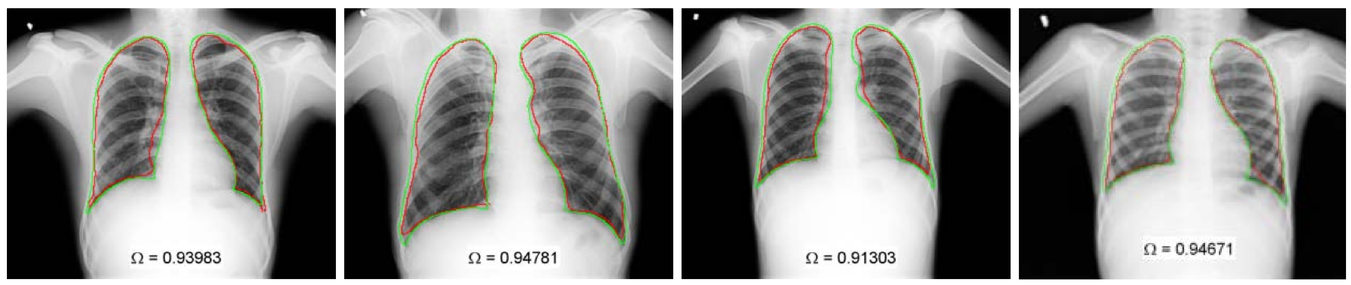
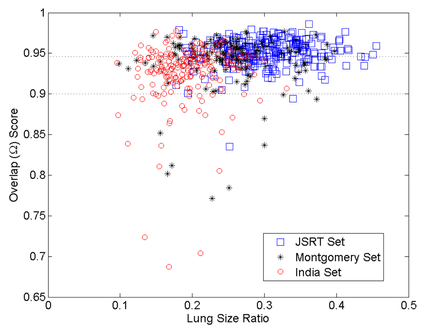
The details of the work will appear in IEEE, Transaction Medical Imaging, 2013.

Results



Green and red contours indicate the gold standard and automatic segmentation results, respectively.

- JSRT set: contains 247 x-rays, among which 154 have lung nodules.
- Montgomery set: 138 x-rays, 58 of them are abnormal with manifestations of tuberculosis.
- India set: 397 x-rays.
- We manually generated gold standard segmentation under the supervision of a radiologist.



	Ω
Proposed System	0.954 ± 0.015
Hybrid Voting [15]	0.949 ± 0.020
PC postprocessed [15]	0.945 ± 0.022
Human Observer [15]	*0.946 ± 0.018*
Fusing-Intensity&ShapePriors [28]	0.940 ± 0.053
Hybrid ASM-PC [15]	0.934 ± 0.037
Hybrid AAM-PC [15]	0.933 ± 0.026
MISCP [31]	0.930 ± 0.045
ASMOF [23]	0.927 ± 0.032
Fuzzy-Curve [7]	0.927 ± 0.033
ASM-SIFT [25]	0.920 ± 0.031
ShRAC [29]	0.907 ± 0.033
ASM-tuned [15]	0.903 ± 0.057
ASM [25]	0.870 ± 0.074
AAM [15]	0.847 ± 0.095
Mean shape [15]	0.713 ± 0.075