Iowa Initiative for Artificial Intelligence

Final Report

Project title:	Pneumothorax Detection in Chest X-rays using Deep Neural Networks
Principal Investigator:	Archana Laroia, MD, Steve Baek, PhD, Sandeep Laroia, MD, Changhyun Lee, MD, PhD
Prepared by (IIAI):	Yanan Liu
Other investigators:	
Date:	

Were specific aims fulfilled:	Y
Readiness for extramural proposal?	N
If yes … Planned submission date	2022-2023
Funding agency	NIH (?)
Grant mechanism	
If no … Why not? What went wrong?	

Brief summary of accomplished results:

We built a pipeline to extract pleural separation from chest x-rays and validated the results vs. independent standards prepared by radiology experts. The prediction accuracy of pneumothorax was 87% and the Pearson correlation between prediction results and ground truth was 0.854.

Research report:

Aims (provided by PI):

1. accomplish rigorous validation of the pneumothorax detection performance of U-Net algorithm (1) on post-biopsy chest x-rays in the Department of Radiology, University of Iowa Hospitals and Clinics. We will collect post-biopsy chest x-rays alongside the ground-truth labels. Such data will be used to validate if the U-Net model trained in our preliminary study can be generalized.

2. Validate the performance of AI technology in detecting the interval change in pneumothorax between the baseline and the follow-up chest x-ray obtained post-procedure. The goal is to test how reliable the AI technology is in filtering out clearly dischargeable patients, by observing the interval change in pneumothorax.

Data:

We have previously performed a data search and obtained 15 Iowa patient cases and 30 pleural separation results from these patients.

AI/ML Approach:

In a prior study, Dr. Baek trained a deep neural network model named U-Net (2) on the Society for Imaging Informatics in Medicine (SIIM) Pneumothorax Challenge data set (3). The training data set was comprised of 10,675 chest X-ray images, among which 2,421 cases were pneumothorax. For each pneumothorax case, a binary mask indicating pneumothorax pixel (1: pneumothorax, 0: normal) was available.

Experimental methods, validation approach:

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The U-Net architecture is comprised of hourglass-shaped symmetric convolutional neural networks, taking a chest X-ray as an input and producing a probability distribution as an output. The binary cross-entropy function was used as an objective function to fit the probability distribution predicted by the model to be as close as possible to the ground truth mask for all training samples. For training, 7,926 normal chest X-rays and 2,093 pneumothorax cases were used. 1,981 normal chest X-rays and 523 images were used to monitor the accuracy and the loss function changes along the training process. The remaining 656 images (328 normal, 328 pneumothorax) were used to test the model, in which the U-Net model performed with 0.81 Dice similarity coefficient (DSC) in detecting the pneumothorax pixels, with 0.36 specificity and 0.94 sensitivity.

Validation Results on Iowa Patients:

Due to limited availability of pleural ground truth, we only validated 30 chest x-rays.

We further attested the model against 30 chest X-ray cases collected internally at the University of Iowa Hospitals and Clinics. For all 30 cases, the model was able to correctly highlight the region of pneumothorax and agreed with expert chest radiologists' opinion. (Figure 1) The pneumothorax prediction accuracy was 87% and the Pearson correlation of prediction and ground truth was 0.854. (Figure 2).

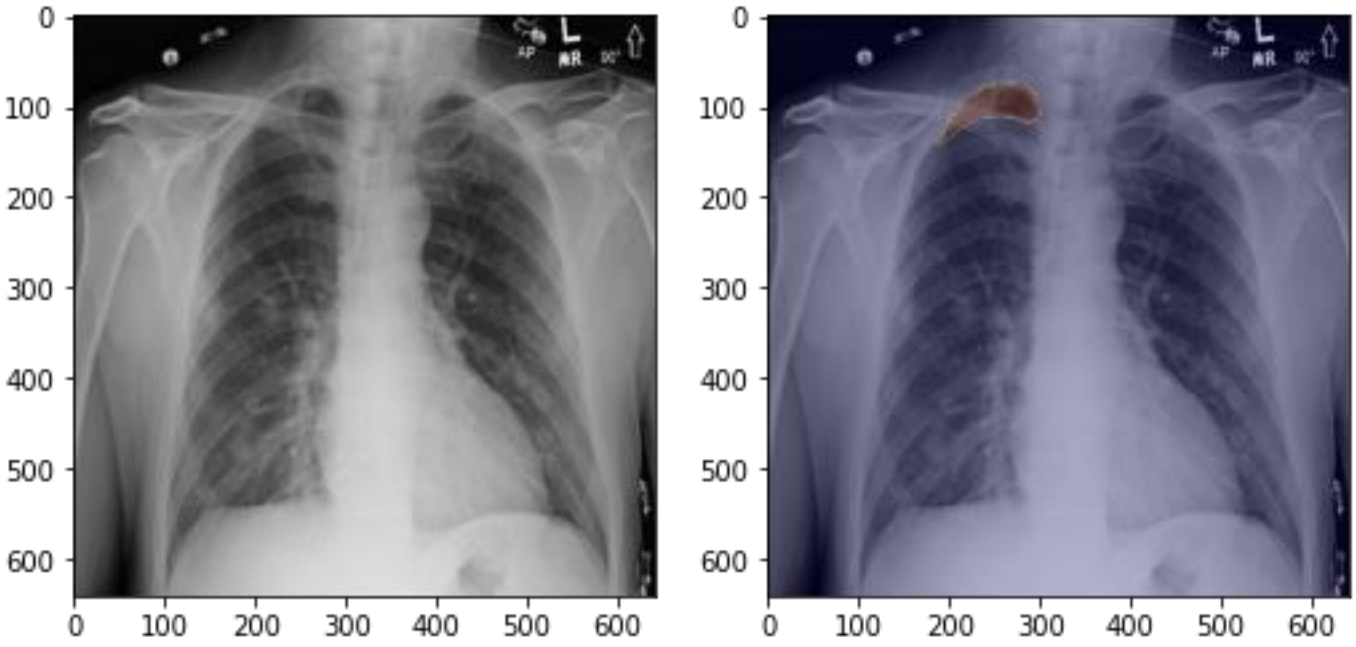

Figure 1. Chest X-rays of pneumothorax case and its detection result.

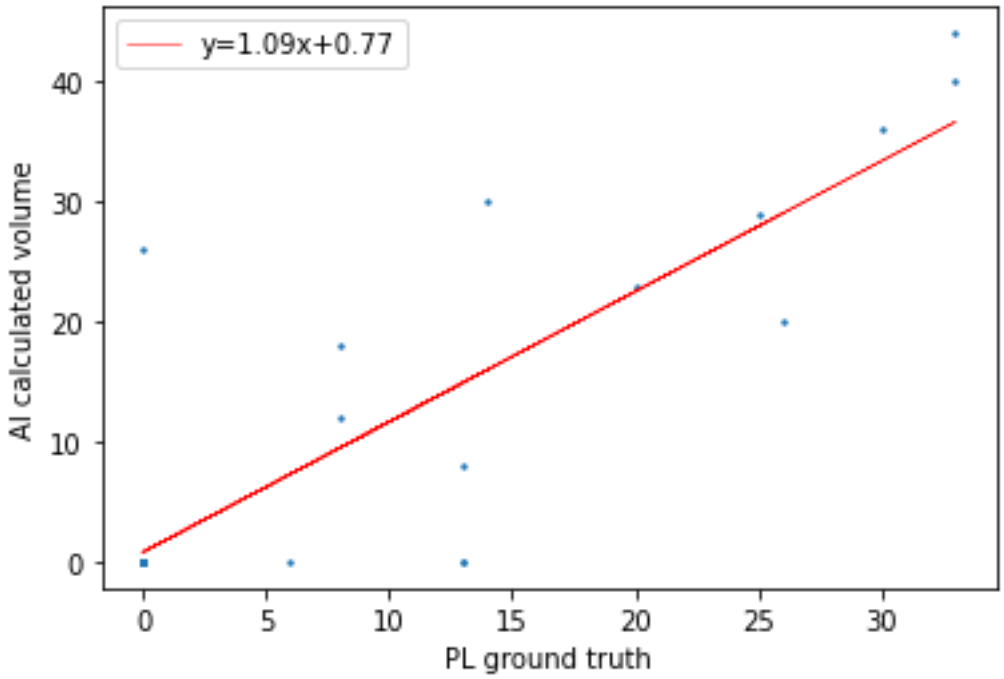

Figure 2. AI calculated results and its ground truth.

Publications resulting from project:

There were no publications resulting from this project.

References:

1.Ronneberger, O., Fischer, P. & Brox, T. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. CoRR, abs/1505.04597.

2. Ross W. Filice; Anouk Stein, M.D.; Carol C. Wu, M.D.; Veronica A. Arteaga, M.D.; Stephen Borstelmann, M.D.; Ramya Gaddikeri, M.D.; Maya Galperin-Aizenberg, M.D.; Ritu R. Gill, M.D., M.P.H.; Myrna C. Godoy, M.D., Ph.D.; Stephen B. Hobbs, M.D.; Jean Jeudy, M.D.; Paras C. Lakhani, M.D.; **Archana Laroia, M.D**.; Sundeep M. Nayak, M.D.; Maansi R. Parekh, M.B.B.S., DNB; Prasanth Prasanna, M.D.; Palmi Shah, M.D.; Dharshan Vummidi, M.D.; Kavitha Yaddanapudi, M.D.; George Shih, M.D., M.S. Crowdsourcing Pneumothorax Annotations using Machine Learning Annotations on the NIH Chest X-Ray Dataset accepted for publication in Journal of Digital imaging

3. Society for Imaging Informatics in Medicine (SIIM), American College of Radiology (ACR) (2019). SIIM ACR Pneumothorax Segmentation Data. https://www.kaggle.com/jesperdramsch/siim-acr-pneumothorax-segmentation-data.