Deep Learning Based Lung Image Segmentation Using XR-U-Net

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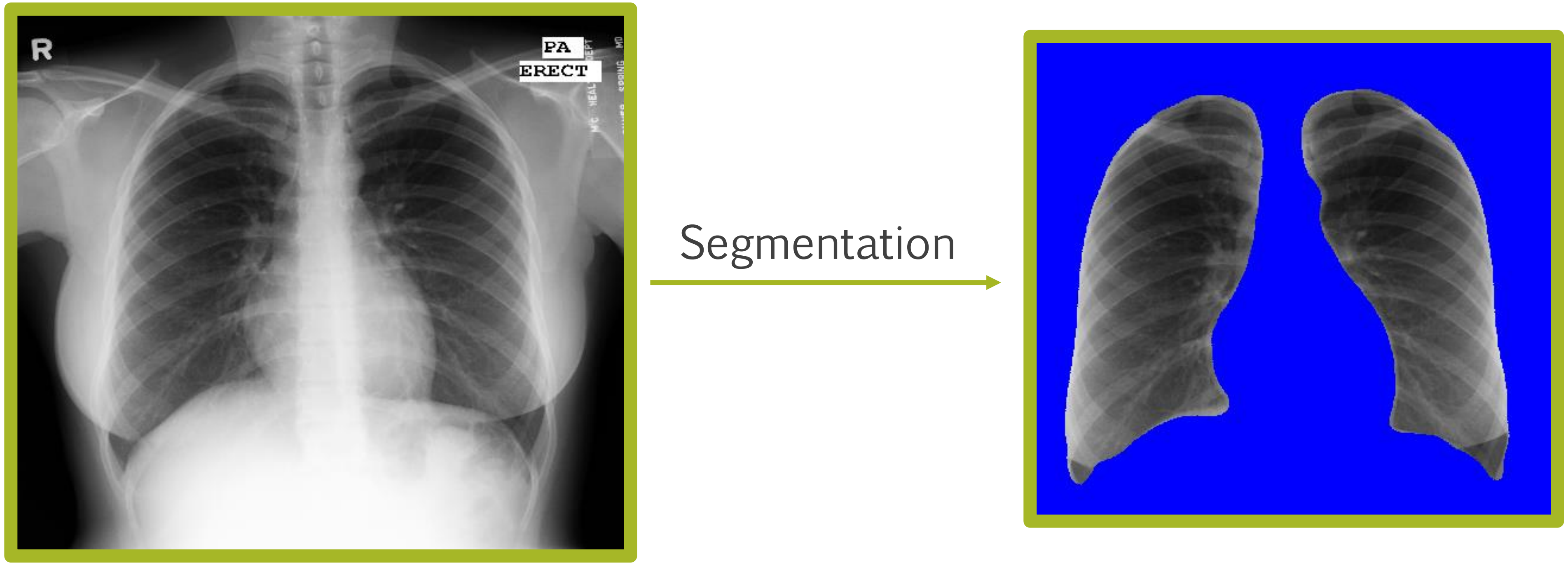
Table of Contents

Lung Image Segmentation

- Lung image segmentation is the process of separating the lung area from medical images like X-rays or CT scans to help doctors understand and treat lung problems.

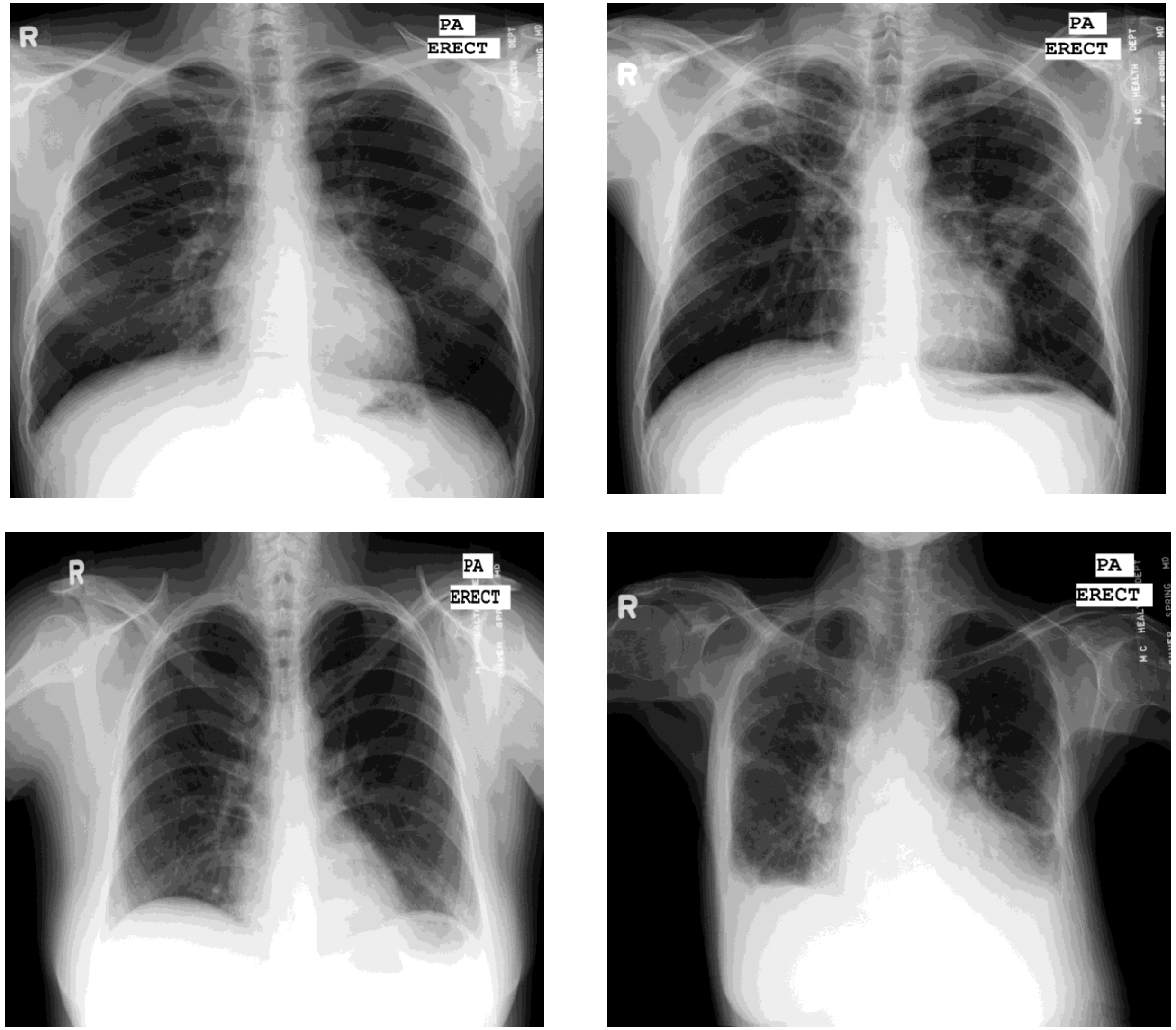


X-Ray and U-Net

- X-ray imaging is widely used and affordable globally.
- Chest X-rays crucial for identifying various lung conditions.
- Over one-third of medical imaging involves chest X-rays.
- U-Net excels in precise segmentation using skip connections.

Our Contributions

- Designed a XR-U-Net with five-layers of encoder-decoder structure.
- Eliminated preprocessing to streamline segmentation workflow.
- Conducted visual evaluations of segmented image results.

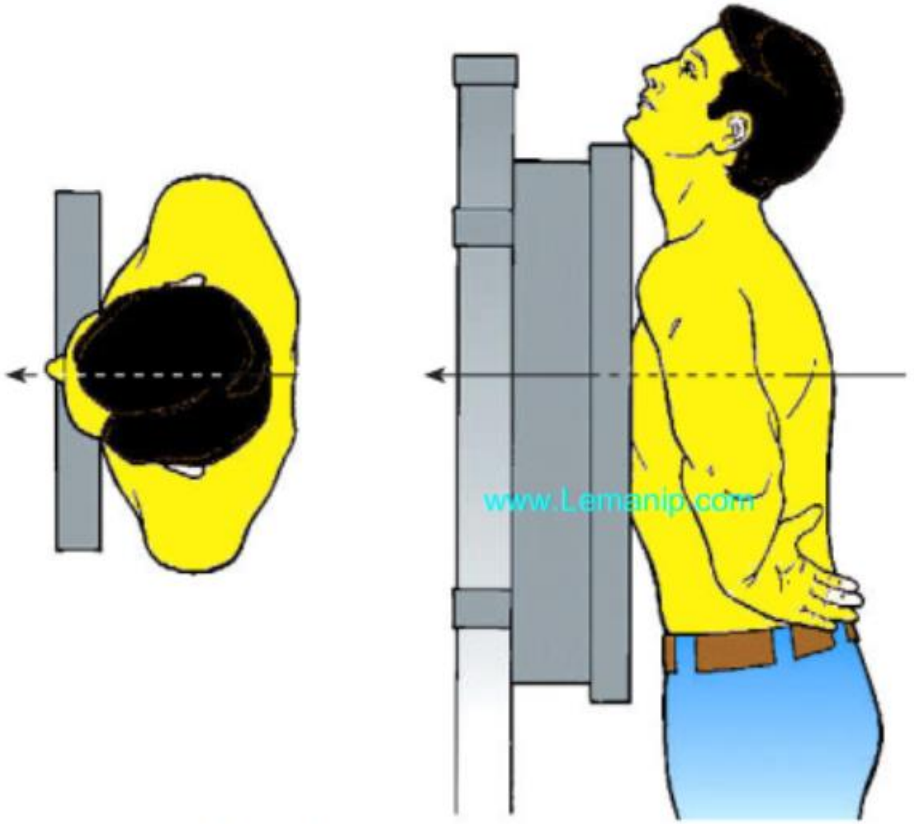


Dataset

- **Source**: X-ray images were obtained from the tuberculosis control program of the Department of Health and Human Services, Montgomery County, MD, USA.
- **Total Images**: The dataset consists of 138 posterior-anterior X-rays.
- **Normal Cases**: 80 X-rays in the dataset are normal.
- **Abnormal Cases**: 58 X-rays show manifestations of tuberculosis.

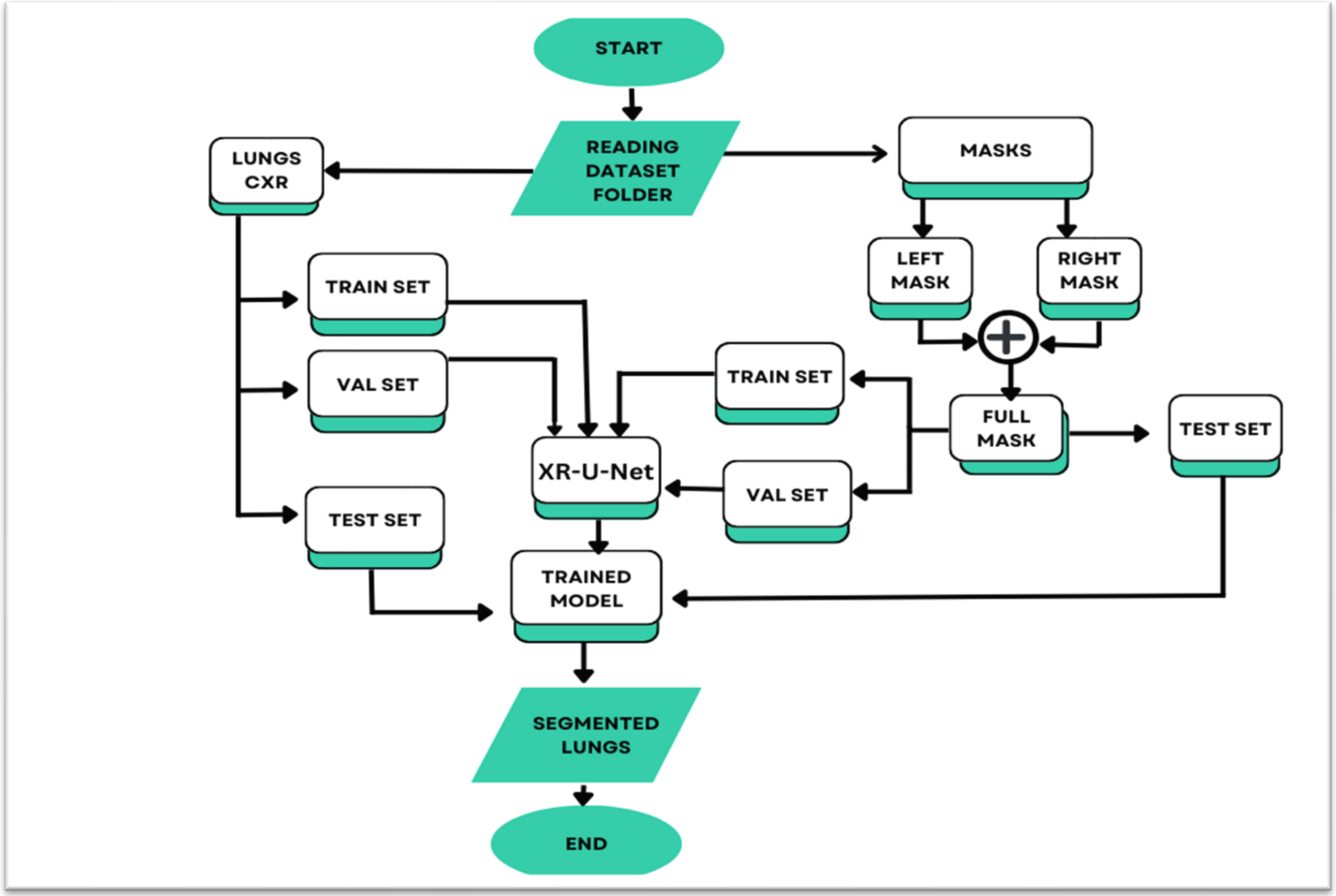
X-Ray Method

- Posterior Anterior projection



PA projection of chest. Central ray enters posterior aspect and exits anterior aspect. Patient is in upright position.

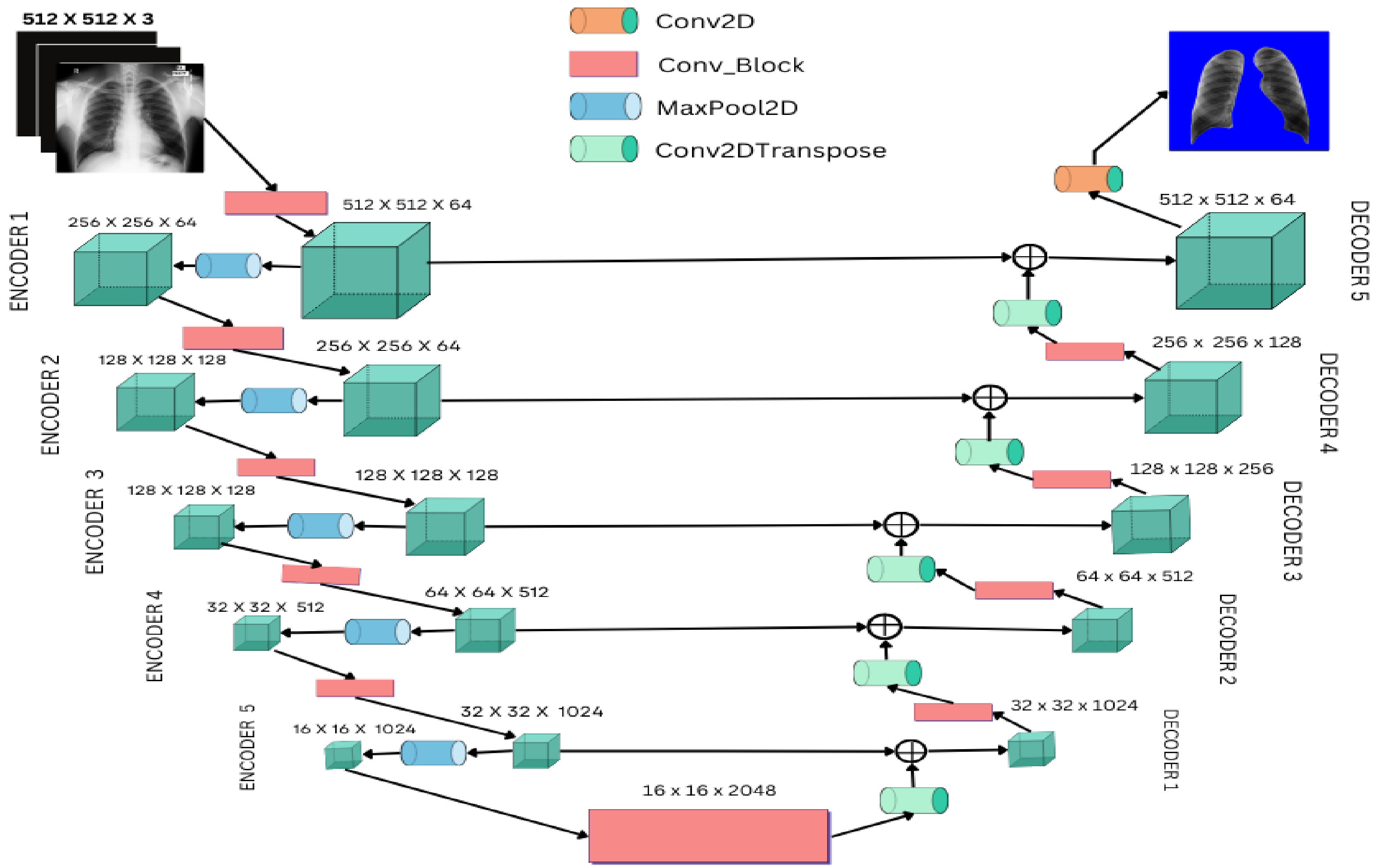
Workflow diagram



Dataset Spliting

- Train dataset contains 112 images.
- Validation dataset contains 13 images.
- Test dataset contains 13 images.

System Architecture



IoU and Dice Coefficient

1. IoU (Intersection over Union)

The IoU measures the ratio of the overlap area (intersection) to the total area covered by the predicted mask and the ground truth mask (union). It is expressed as:

$$\text{IoU} = \frac{\text{Area of Intersection}}{\text{Area of Union}}$$

2. Dice Coefficient

The Dice Score measures the similarity between the predicted mask and the ground truth mask. It is computed as:

$$\text{Dice Score} = \frac{2 \times \text{Area of Intersection}}{(\text{Area of Predicted Mask} + \text{Area of Ground Truth Mask})}$$

Training Curves

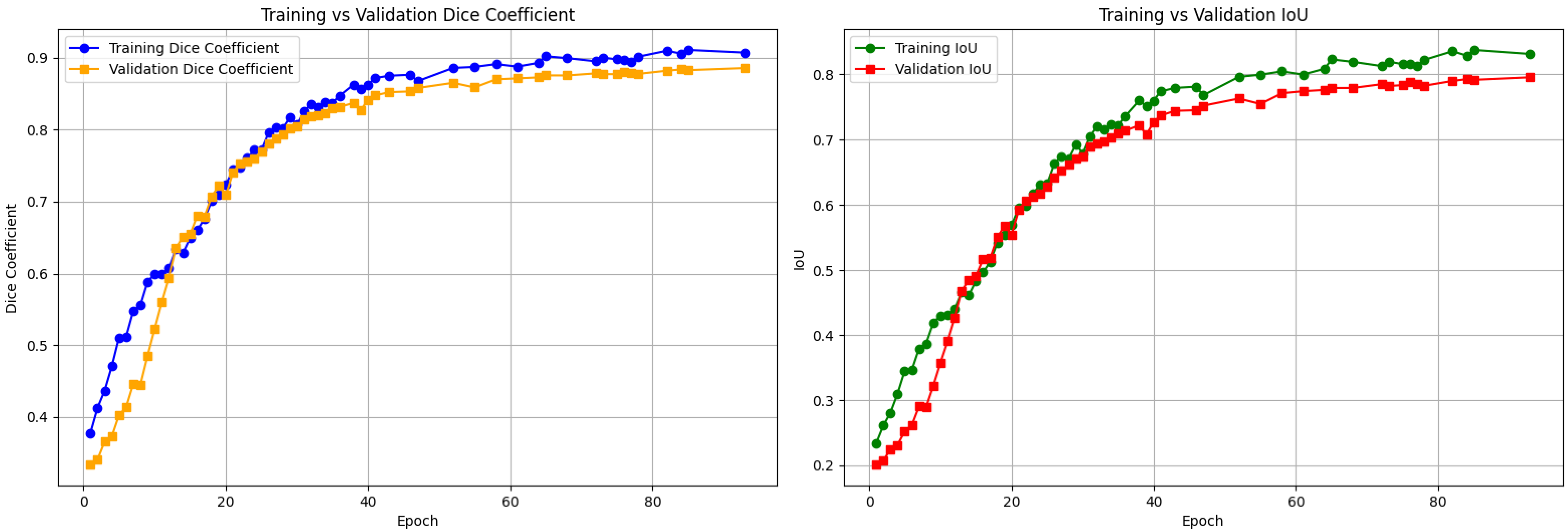
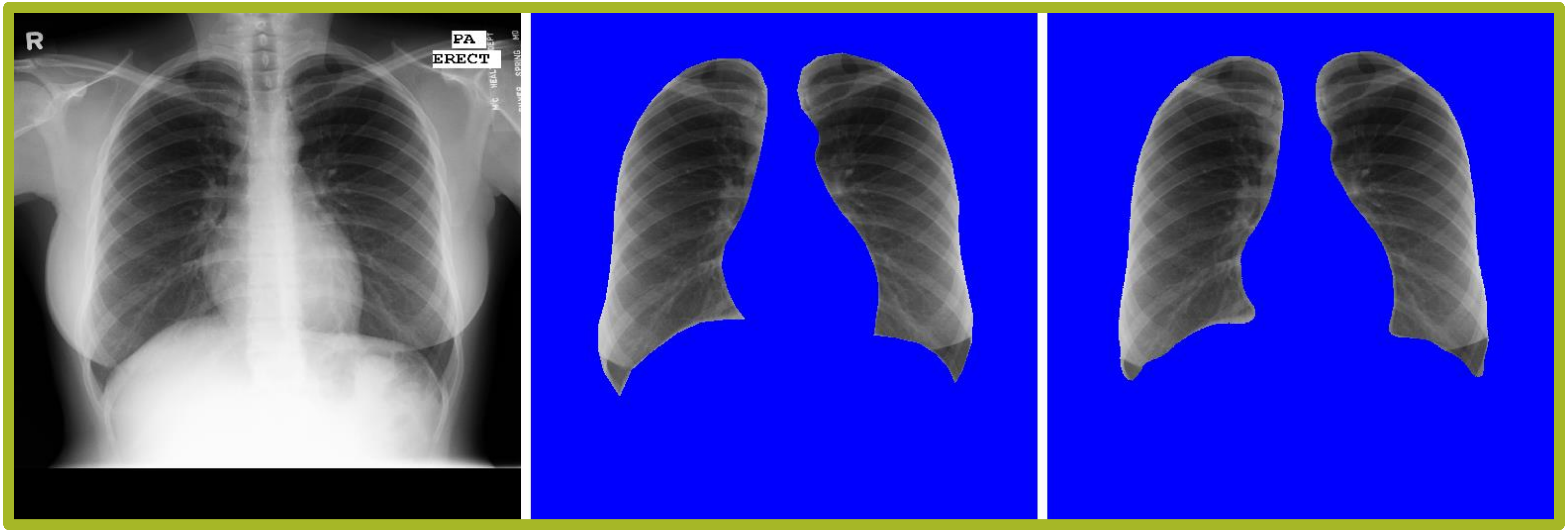


Figure 1: Training graph, the left side presents the training vs validation dice coefficient curve and the right side presents the training vs validation IoU graph.

Evaluation



(a) (b) (c)

Figure 2: Lung CXR images a) input image b) ground truth segment, and c) predicted segment

Evaluation

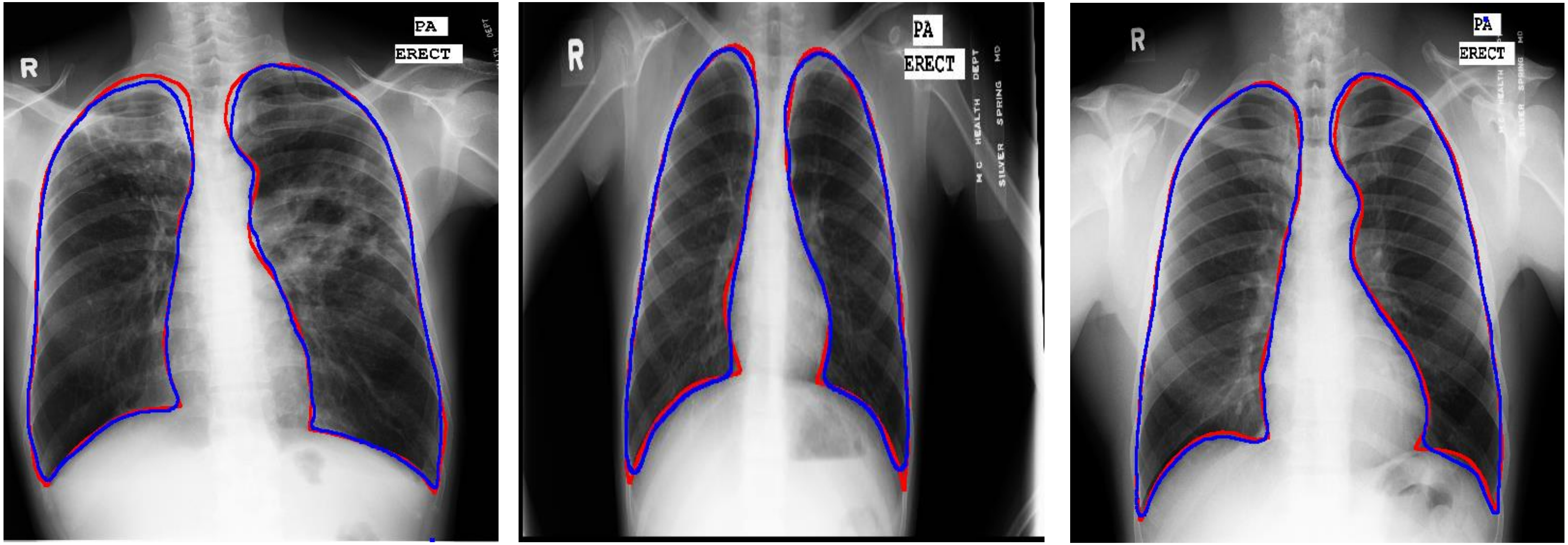


Figure 3: Comparison of segmentation results. The red border indicates the edges of ground truth mask, whereas the blue border indicates the edges of predicted mask.

Comparative study

References	Methods	Dataset	Accuracy
Kumar et al. [1]	FCNN	JSRT	97%
Boodi et al. [2]	U-Net	Custom	98%
Pasa et al. [3]	CNN	Custom	86.6 %
Mique et al. [4]	Deep Residual U-Net	Not specified	Not specified
Gite et al. [5]	U-Net++	Montgomery County X-ray Set	98 %
Proposed	**XR-U-Net**	**Montgomery County X-ray Set**	**95.7 %**

Limitations

- Dataset lacks diversity, limiting model's generalizability.
- Study focuses only on two-dimensional segmentation.
- Minor discrepancies observed in intricate lung structures.
- No integration with advanced diagnostic frameworks yet.

Future Work

- Incorporation of Larger and Diverse Datasets
- Assessment of Heart Size
- Detection of Cardiomegaly

References

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[2] D. Boodi, N. Sudheer, A. P. Bidargaddi, S. Shatagar, and M. Telkar, "Semantic Segmentation of Computed Tomography Scan of Lungs," 2024 5th International Conference for Emerging Technology (INCET), Belgaum, India, 2024, pp. 1-7, doi:10.1109/INCET61516.2024.10593534.

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[4] E. Mique and A. Malicdem, "Deep Residual U-Net Based Lung Image Segmentation for Lung Disease Detection," IOP Conference Series: Materials Science and Engineering, vol. 803, no. 1, p. 012004, Apr. 2020. doi: 10.1088/1757-899X/803/1/012004.

[5] S. Gite, A. Mishra, and K. Kotecha, "Enhanced lung image segmentation using deep learning," Neural Computing and Applications, vol. 35, pp. 22839–22853, 2023. doi: 10.1007/s00521- 021-06719-8


THANK YOU!