SegLungAI

Neonatal Lung Segmentation Using AI

Team Members & Advisor

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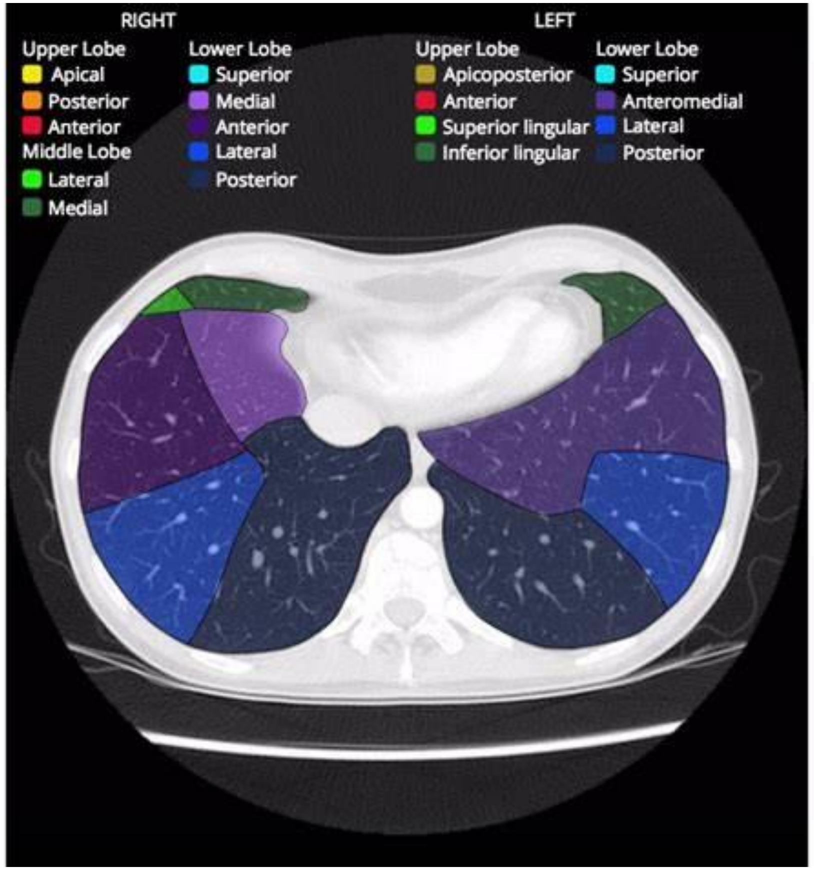
Introduction and Background

Problem Statement:	Neonatal MRI: small anatomy, low contrast, motion artifacts Manual contouring → weeks per case
Clinical Relevance:	Accurate lung segmentation aids early diagnosis of neonatal diseases (e.g., bronchopulmonary dysplasia).
Motivation:	Automating segmentation significantly reduces radiologist workload and accelerates clinical decision-making.

Manual Annotation Burden

Imagine having to annotate 80+ slices by hand:



Click on the image to interact with the visualization:
https://radiopaedia.org/cases/54511/studies/60738?lang=us

Project Goal

Develop a supervised deep learning model that gives neonatal lung segmentation in MRI scans in mere seconds.

Primary Objectives:

Automate lung segmentation in neonatal MRI scans.	Reduce manual annotation time, increase reproducibility.	Enable clinical-scale batch processing

Project Abstract

- **Purpose**: Develop a machine learning model to automatically segment lung regions in neonatal MRI scans.
- **Technique**: Leverages semantic segmentation with a ResNet-50 backbone for high accuracy.
- **Challenges Addressed**: Tackles unique issues in neonatal imaging (e.g., small anatomy, image variability).
- **Resources**: Utilizes open-source tools and institutional resources for scalability and efficiency.
- **Collaboration**: Incorporates feedback from medical professionals to align with clinical needs.
- **Impact**: Streamlines diagnostic workflows and improves precision in detecting lung anomalies.

Method

Data Collection & Preprocessing:

- Initial dataset: 13 neonatal MRI scans (due to ethical and logistical challenges).
- Image reorientation to standard orientation and voxel size normalization (1 mm^3).
- Extensive data augmentation to compensate for limited dataset:
- Rotations ±15°, translations ±5%, zoom ±15%, horizontal flips.

Model Architecture:

- Customized U-Net architecture with ResNet-50 backbone (pre-trained on ImageNet).
- Encoder-decoder structure with skip connections for multi-scale feature extraction.
- Sigmoid activation for pixel-level segmentation probability.

Training and Evaluation

Training Strategy:

- Loss Function: Combined Dice Loss + Weighted Binary Cross Entropy (BCE).
- Optimizer: Adam (learning rate: 1e-4).
- Techniques: Early stopping, ReduceLROnPlateau scheduler.

Evaluation Metrics:

- Dice coefficient (primary metric).
- Intersection over Union (IoU), ROC AUC.
- Robust validation strategy: 70% training, 20% validation, 10% test split.

Technologies

Frameworks

TensorFlow

Keras

Segmentation Models

Preprocessing

NiBabel

scikit-image

OpenCV

Metrics & Plots

MedPy (Hausdorff)

Matplotlib

seaborn

Environment

Python 3.8+

ubuntu

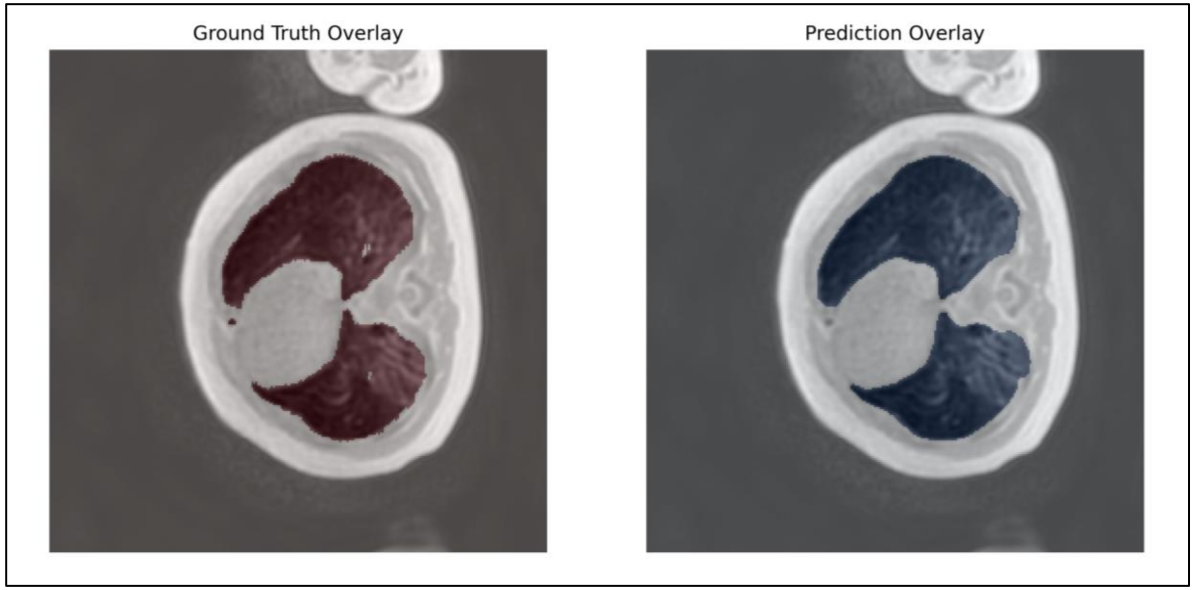
GPU acceleration

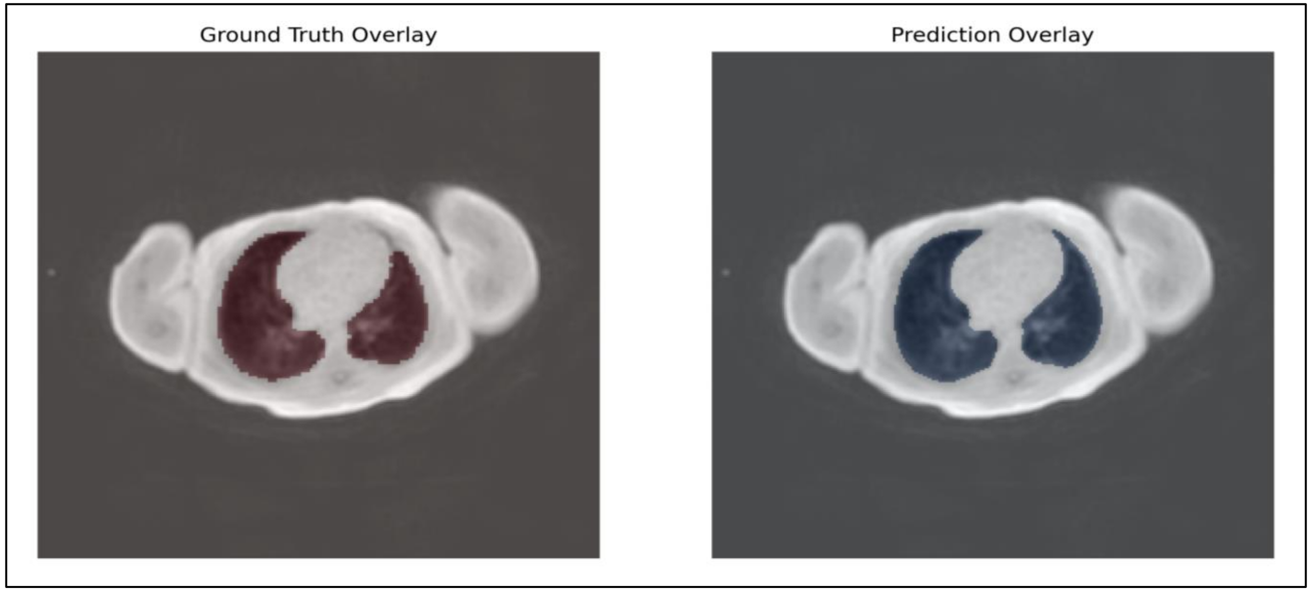
NVIDIA CUDA

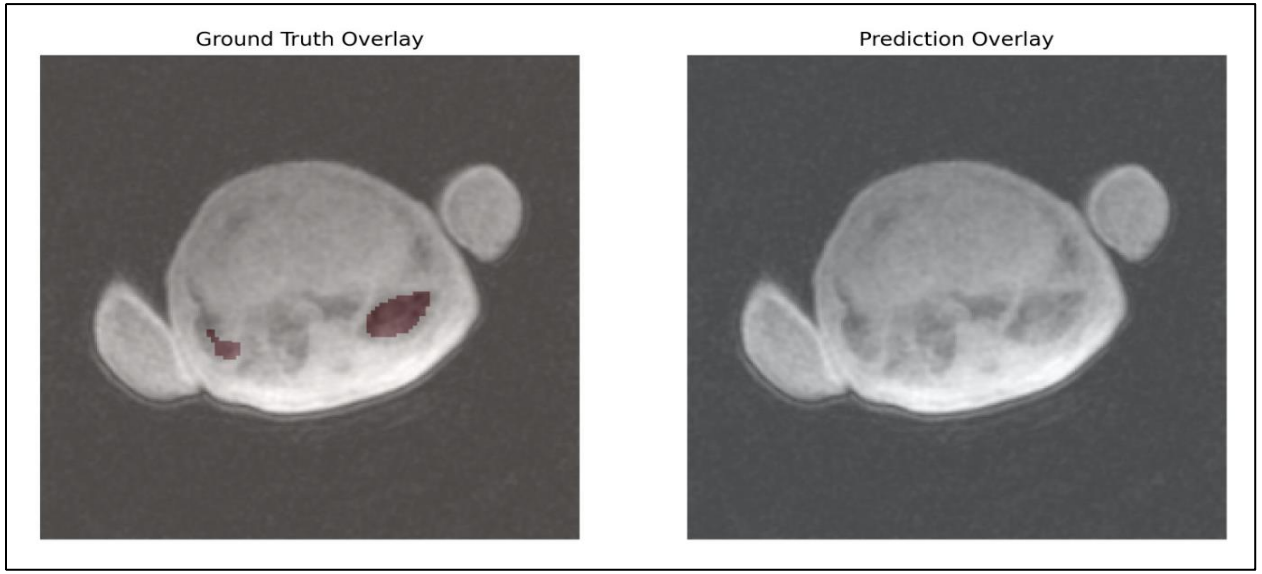
Results

- Segmentation Performance:
  - Mean Dice Score: ~0.90 on validation.
  - IoU range: ~0.83–0.85.
  - ROC AUC: 0.999 (highly accurate separation of lung vs. background).

Comparison plots







Major Project Constraints

Economic:

- Limited to open-source tools and institutional resources.

Professional:

- Requires expertise in semantic segmentation and medical imaging.

Ethical:

- Ensure patient data anonymity and secure storage.

Legal:

- Compliance with HIPAA and intellectual property regulations.

Limitations and Challenges

Limited Dataset:

- Only 13 neonatal scans initially available, impacting generalizability.

Slice-wise Processing:

- 2D segmentation ignores 3D spatial context, possibly leading to inconsistent segmentation between slices.

Annotation Inaccuracies:

- Manual ground truth annotations occasionally inaccurate or inconsistent.

Sensitivity to Artifacts:

- Model sensitive to motion artifacts and presence of medical equipment.

Future Work

Dataset Expansion:

- Collaborate with other centers to acquire larger neonatal datasets.

nnU-Net Implementation:

- Integrate nnU-Net framework for optimized segmentation performance tailored to neonatal MRI scans, leveraging automated hyperparameter tuning and preprocessing optimizations.

Advanced Post-processing:

- Apply morphological filtering and anatomical constraints to improve predictions.

External Validation:

- Validate model performance on external datasets.

User Interface Development:

- Create clinician-focused software to facilitate adoption in clinical workflows.

Project Impact & Conclusion

- Clinical Impact:
  - Automates a previously tedious manual segmentation task.
  - Reduces segmentation time from months of manual annotation to seconds per scan.
- Research Contribution:
  - Tailored deep-learning model specifically addressing neonatal imaging challenges.
- Conclusion:
  - Successfully developed a reliable, efficient neonatal-specific lung segmentation model despite dataset limitations, significantly improving the clinical diagnosis process.

User Stories

1. As a radiologist, I want a tool that automates lung segmentation in neonatal MRI scans so that I can reduce time spent on manual annotations.
2. As a medical researcher, I want a reliable and reproducible AI pipeline so that I can analyze large datasets of neonatal chest images more efficiently.
3. As a neonatal clinician, I want accurate lung segmentation outputs to assist in identifying anomalies, ensuring better patient outcomes.

Accomplishments

- Fully functional segmentation model.
- Automated pipeline for neonatal MRI scans.
- Comprehensive documentation and evaluation metrics.
- Deliverables for the Expo presentation.

Division of Work

I will be working alone on this project under the guidance of advisor Jason Woods, PhD with the collaboration of Alex Matheson, PhD, Abdullah Bdaiwi, PhD

Thank You!

We hope you found our presentation informative.

For questions or feedback, please contact us at patel4du@mail.uc.edu.