Deep Learning - CS 437

Organ and Tumor Segmentation with Lesion Detection in CT Scans

We are focusing on cancer, aiming to develop an AI-based system for automated tumor segmentation in CT scans using deep learning.

This project is supported by the Northern Rhode Island Hematology Oncology Program, providing clinical insight to help align our work with real-world medical needs.

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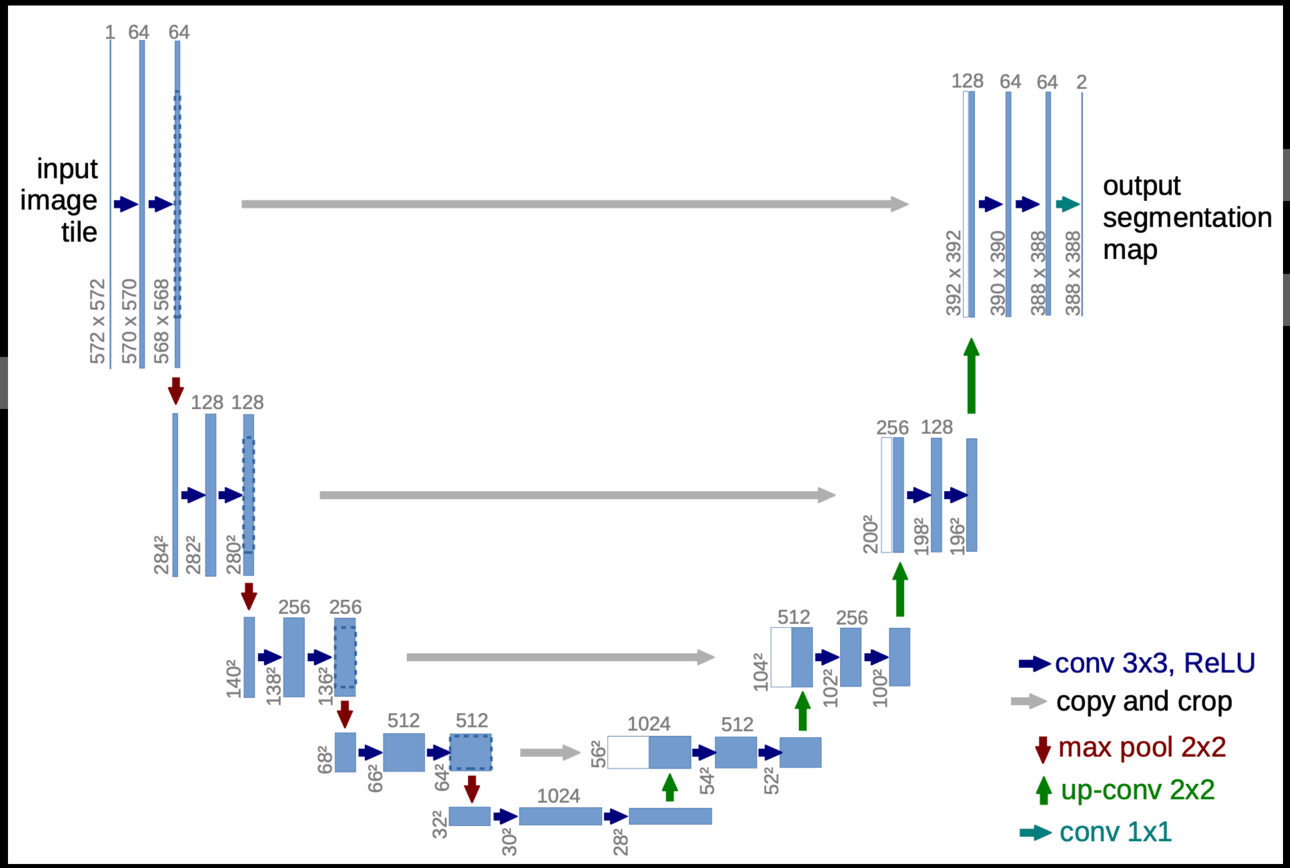
U-Net: Convolutional Networks for Biomedical Image Segmentation

Olaf Ronneberger, Philipp Fischer, and Thomas Brox

Computer Science Department, University of Freiburg, Germany

What the Paper is About:

• Introduces U-Net, a deep learning architecture specifically designed for biomedical image segmentation.
• Optimized for precise pixel-wise segmentation with very few annotated training samples.
• Uses a symmetric encoder-decoder structure with skip connections.



Key Contributions/Relevance to Our Project:

• Solves the context vs. localization problem: maintains spatial accuracy while capturing global features.

• Introduced data augmentation via elastic deformation — vital when labeled data is limited (like in medical imaging).

• Designed to work well with limited data, aligning with real-world medical imaging challenges.

• Demonstrates a clear advantage over patch-based methods (sliding window CNNs) in speed and accuracy.

Artificial Intelligence Radiotherapy Planning: Automatic Segmentation of Human Organs in CT Images Based on a Modified CNN

Guosheng Shen, Xiaodong Jin, Chao Sun, Qiang Li

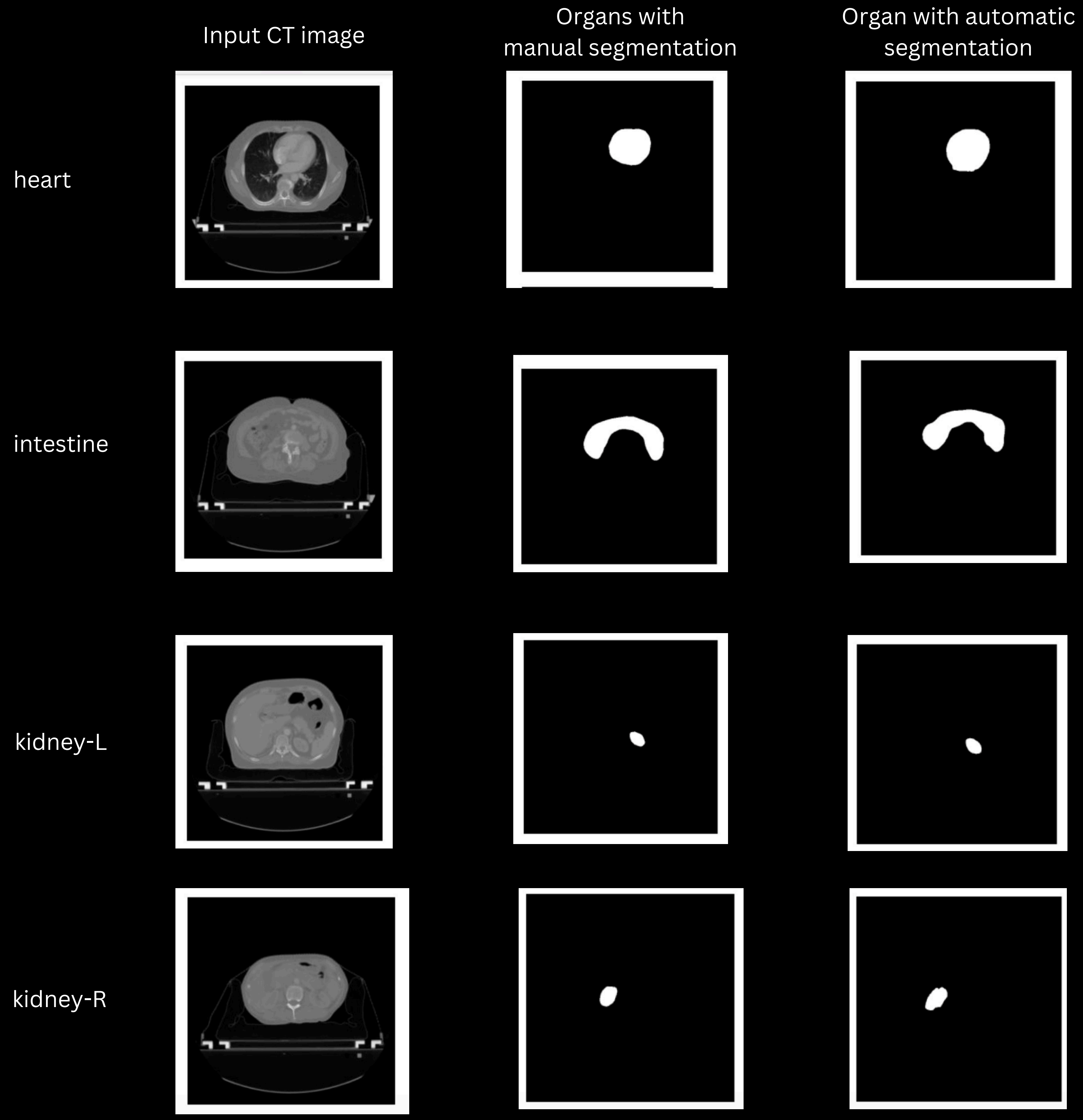
What the Paper is About:

This study presents a modified deep learning model based on BCDU-Net (Bi-Directional ConvLSTM U-Net with Dense Connections) for automatic segmentation of 17 human organs in CT scans to improve radiotherapy planning.

The model is trained on 22,000 CT scans from 339 patients, achieving high accuracy and fast prediction, making it suitable for clinical applications.

Key Contributions/Relevance to Our Project:

- Modified U-Net architecture (BCDU-Net) that integrates ConvLSTM and Dense Blocks for better feature extraction.
- Achieved an average Dice score of 0.8376, with best reaching 0.9676.
- Validates using U-Net-style architectures for organ segmentation in CT images.
- Confirms the clinical value of accurate AI segmentation tools.
- Strong foundation for extending to tumor segmentation and volume estimation.



Machine Learning-Based Lung Cancer Detection Using Multiview Image Registration and Fusion

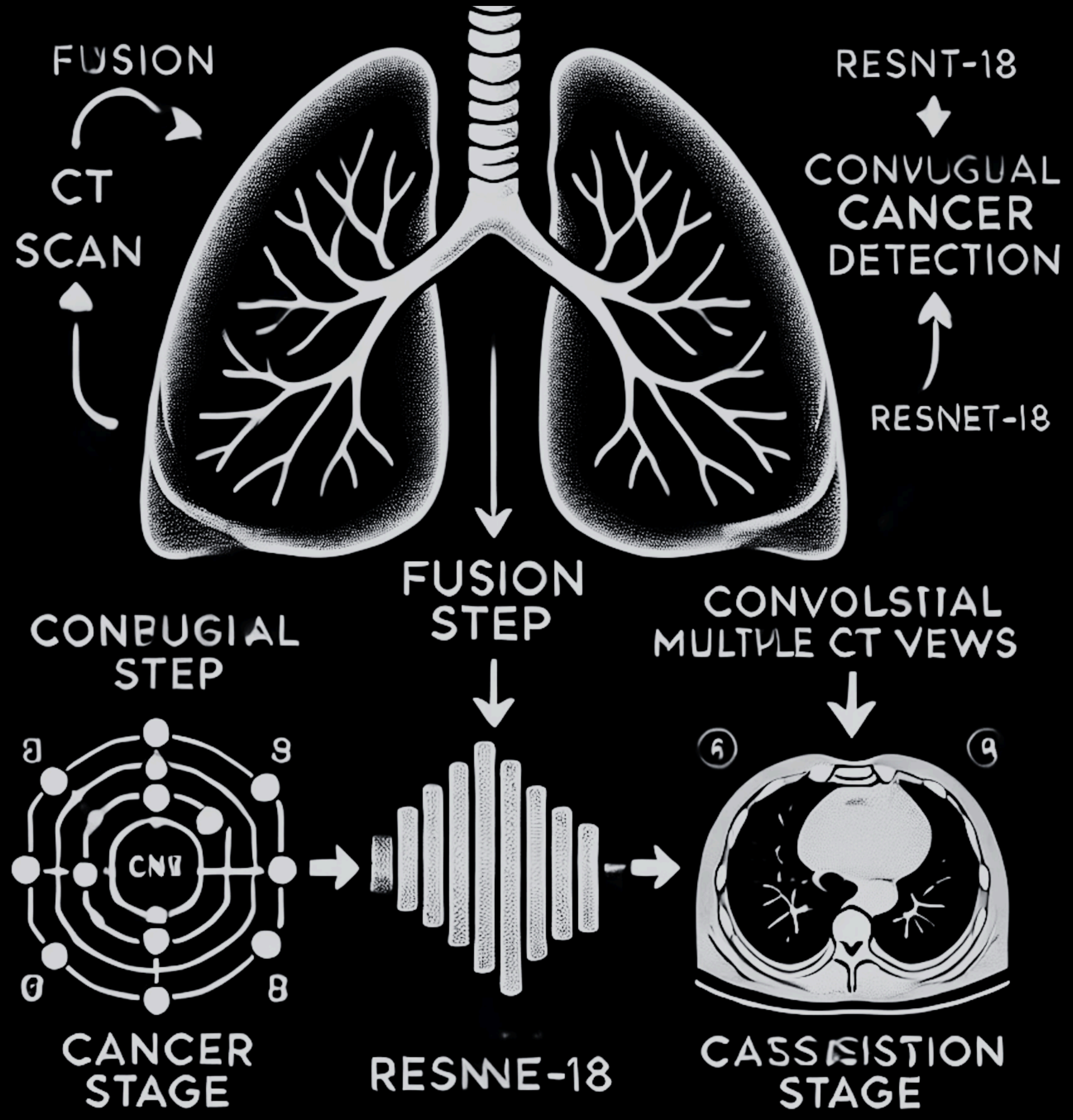
Imran Nazir et al. (2023), Journal of Sensors

What the Paper is About:

This paper proposes a machine learning-based framework for detecting and classifying lung cancer stages using multiview CT scan image fusion and ResNet-18 CNN. The method combines multiple images using advanced image registration and fusion techniques to improve tumor visibility and detection accuracy.

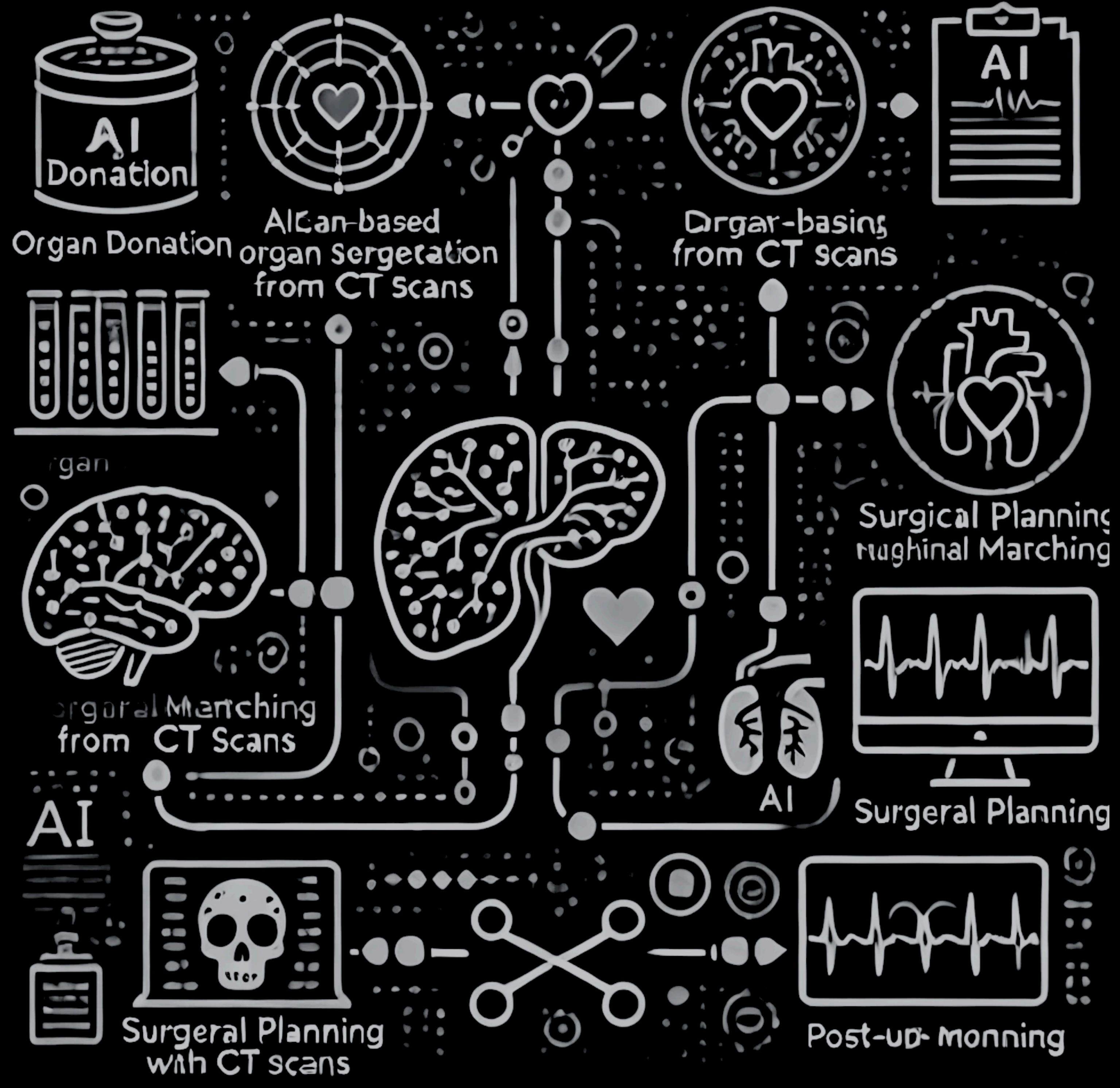
Key Contributions/Relevance to Our Project:

- Validates the use of machine learning and CNNs for lung cancer detection.
- Provides a pipeline: CT preprocessing → image fusion → segmentation → stage classification.
- Strong accuracy metrics (e.g., 98.2% accuracy, 96.4% sensitivity) support potential for clinical use.
- Introduces fusion-based enhancement which we could explore as a future add-on to our segmentation model.



The Impact of Artificial Intelligence and Machine Learning in Organ Retrieval and Transplantation: A Comprehensive Review

David B. Olawade et al. (2025)



What the Paper is About:

This is a comprehensive review of how AI and ML are being used across the entire organ transplantation pipeline, from donor-recipient matching to surgical planning, post-operative monitoring, and resource optimization in transplant centers.

Key Contributions/Relevance to Our Project:

- Validates the clinical need and value of accurate organ segmentation using AI (which our project focuses on).
- Reinforces the role of segmentation in larger systems like surgical planning and transplant success.
- Confirms that models like U-Net are foundational in AI-based imaging tasks in transplantation.
- Shows the use of real-time AI surgical guidance systems and remote post-op monitoring.

Project Scope

Project Workflow:

1. Problem Definition & Clinical Motivation
• Aim: Automate tumor segmentation in CT scans to aid early diagnosis and treatment planning.

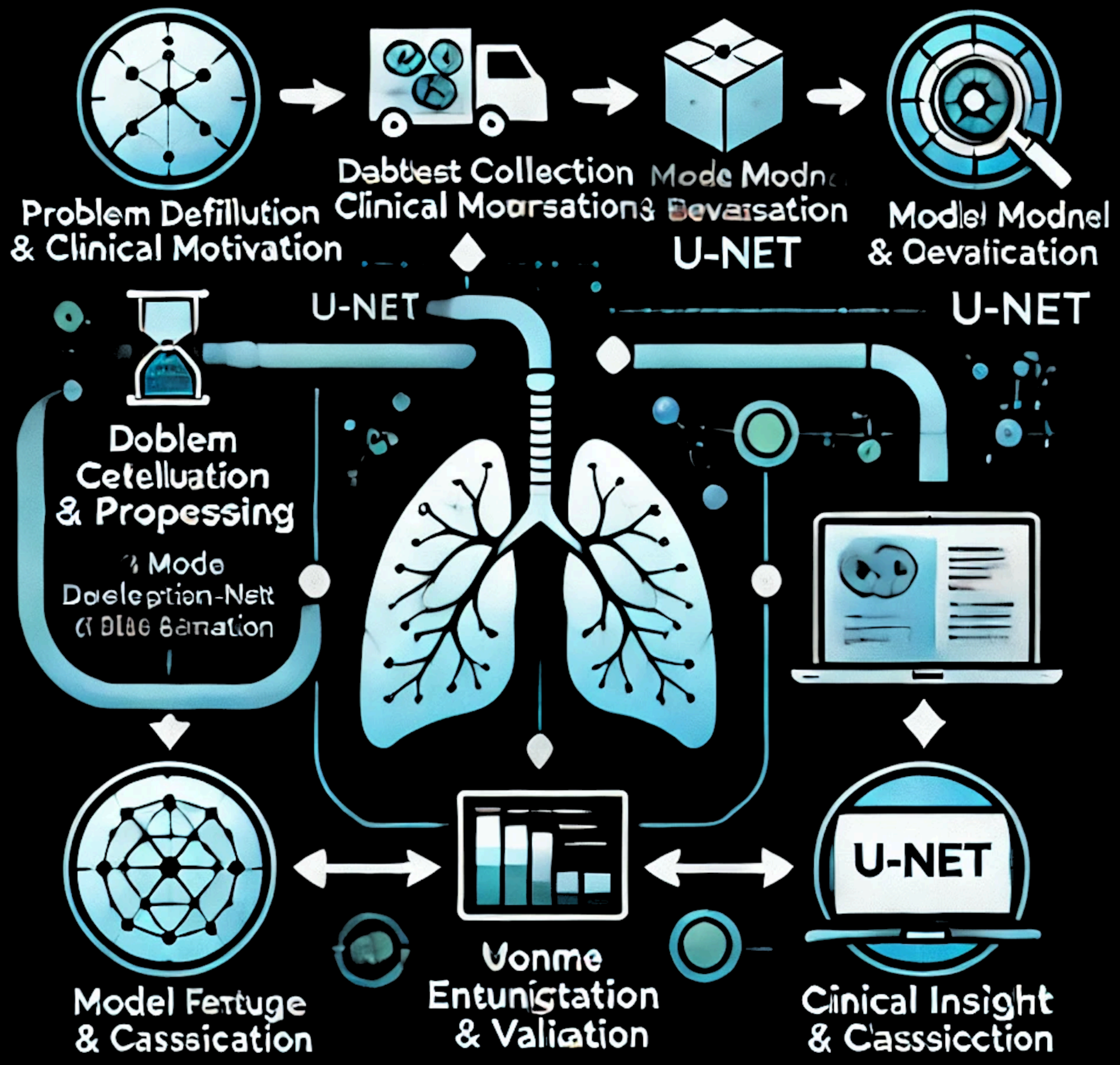
2. Dataset Collection & Preprocessing
• Use the LIDC-IDRI dataset (publicly available lung CT scans with annotated nodules).
• Preprocess CT scans:
• Normalize Hounsfield Units (HU)
• Convert DICOM to image slices
• Extract and align tumor masks with image data

3. Model Development (U-Net)
• Implement a 2D U-Net model using PyTorch and MONAI.
• Train it to perform pixel-level segmentation of lung nodules.

4. Model Evaluation
• Use metrics like Dice coefficient, IoU, precision, and recall.
• Visualize results and analyze performance on unseen CT scans.

5. Clinical Insight & Validation
• Get segmentation outputs reviewed by a specialist from the Northern Rhode Island Hematology Oncology Program to validate practical usefulness.

6. Bonus Features (Optional)
• Estimate tumor volume from segmented slices.
• Classify tumor regions (e.g., benign vs malignant) using a CNN like ResNet.



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Expected Impact of the Project

• Provide a quick and accurate tool for lung tumor segmentation, reducing radiologist workload.

• Demonstrate the real-world application of deep learning in medical imaging.

• Bridge the gap between academic AI models and clinical workflows.

How the Project Can Be Expanded:

Real-time Clinical Tool
• Build a web interface or mobile app for doctors to upload CT scans and get instant segmentation + volume estimation.

Multimodal Fusion
• Merge CT scan data with clinical records or genetic markers for richer diagnostics.

Switch to 3D Segmentation
• Upgrade from 2D U-Net to 3D U-Net for volumetric CT scan analysis.

Semi-Supervised Learning
• Reduce reliance on labeled data using pseudo-labeling or consistency training to segment tumors from unlabeled scans.