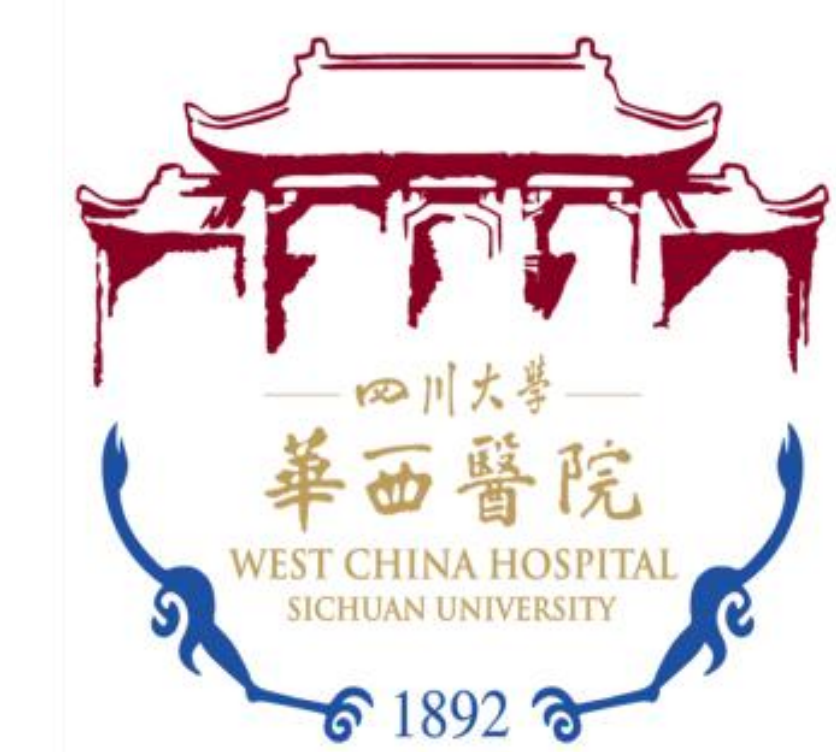




Accurate Prediction of Thoracic Lymph Nodes Based on a Two-Stage Cascaded U-Net Model

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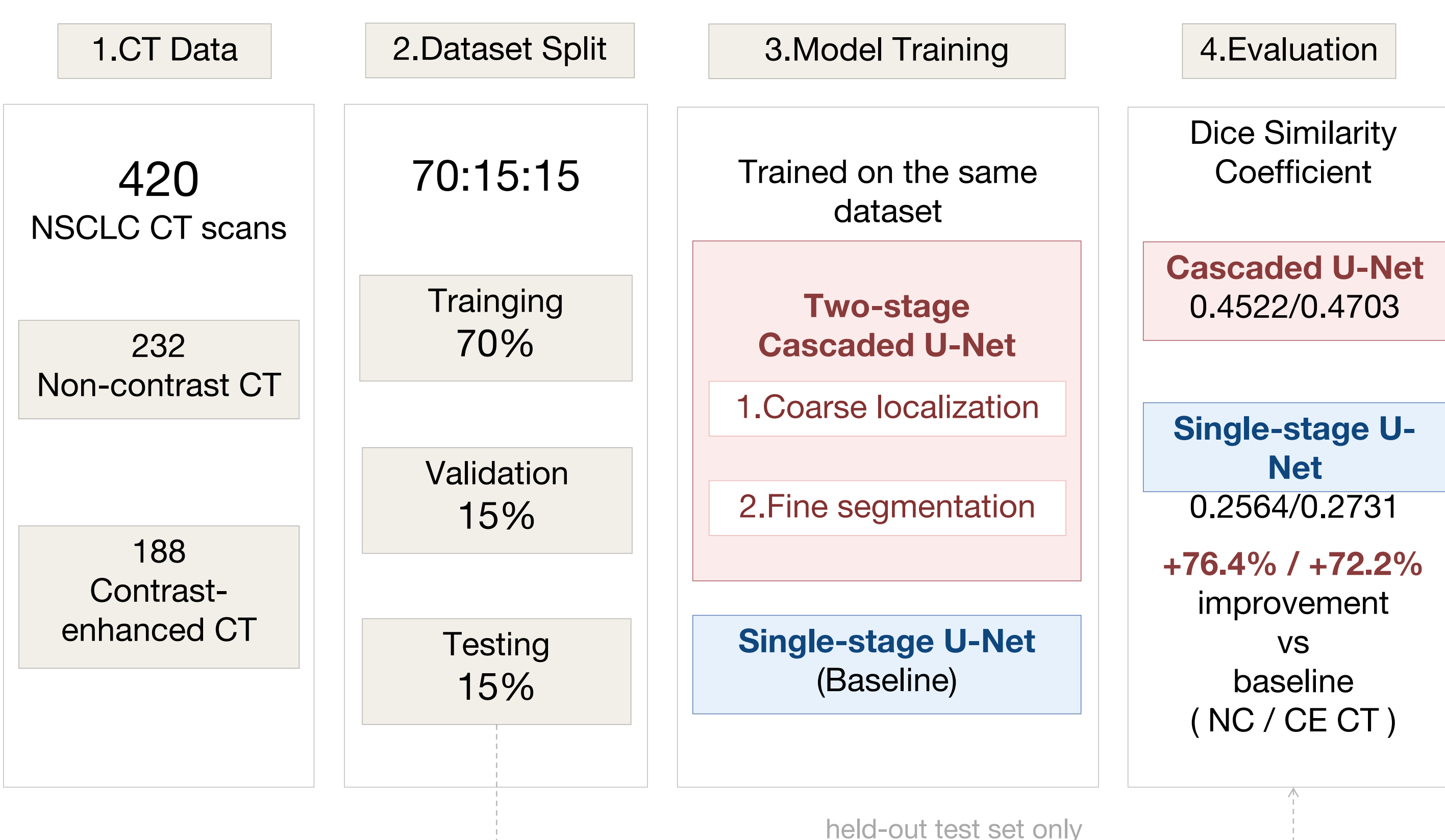
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INTRODUCTION

- Mediastinal lymph node status is critical for accurate lung cancer staging.
- Current NCCN guidelines recommend invasive biopsy (EBUS/mediastinoscopy), but these procedures are costly, risky, and poorly tolerated.
- A non-invasive and accurate predictive model is urgently needed in clinical practice.
- We developed a two-stage cascaded U-Net for thoracic LN segmentation on 3D CT, as a foundation for future AI-assisted nodal staging.

METHODS

- Study design: Retrospective imaging study.
- Dataset: 420 CT scans from NSCLC patients (232 non-contrast, 188 contrast-enhanced).
- Split: Training (70%), validation (15%), test (15%).
- Model architecture:
 - Two-stage cascaded U-Net (coarse-to-fine).
 - Stage 1: Coarse localization of candidate LN-containing regions.
 - Stage 2: Fine segmentation within cropped ROIs – enhances boundary delineation, especially for small LNs.
- Baseline: Conventional single-stage U-Net trained on same data.
- Evaluation metric: Dice similarity coefficient (DSC).



RESULTS

Two-stage cascaded U-Net achieved:

DSC = 0.4522 (non-contrast CT)

DSC = 0.4703 (contrast-enhanced CT)

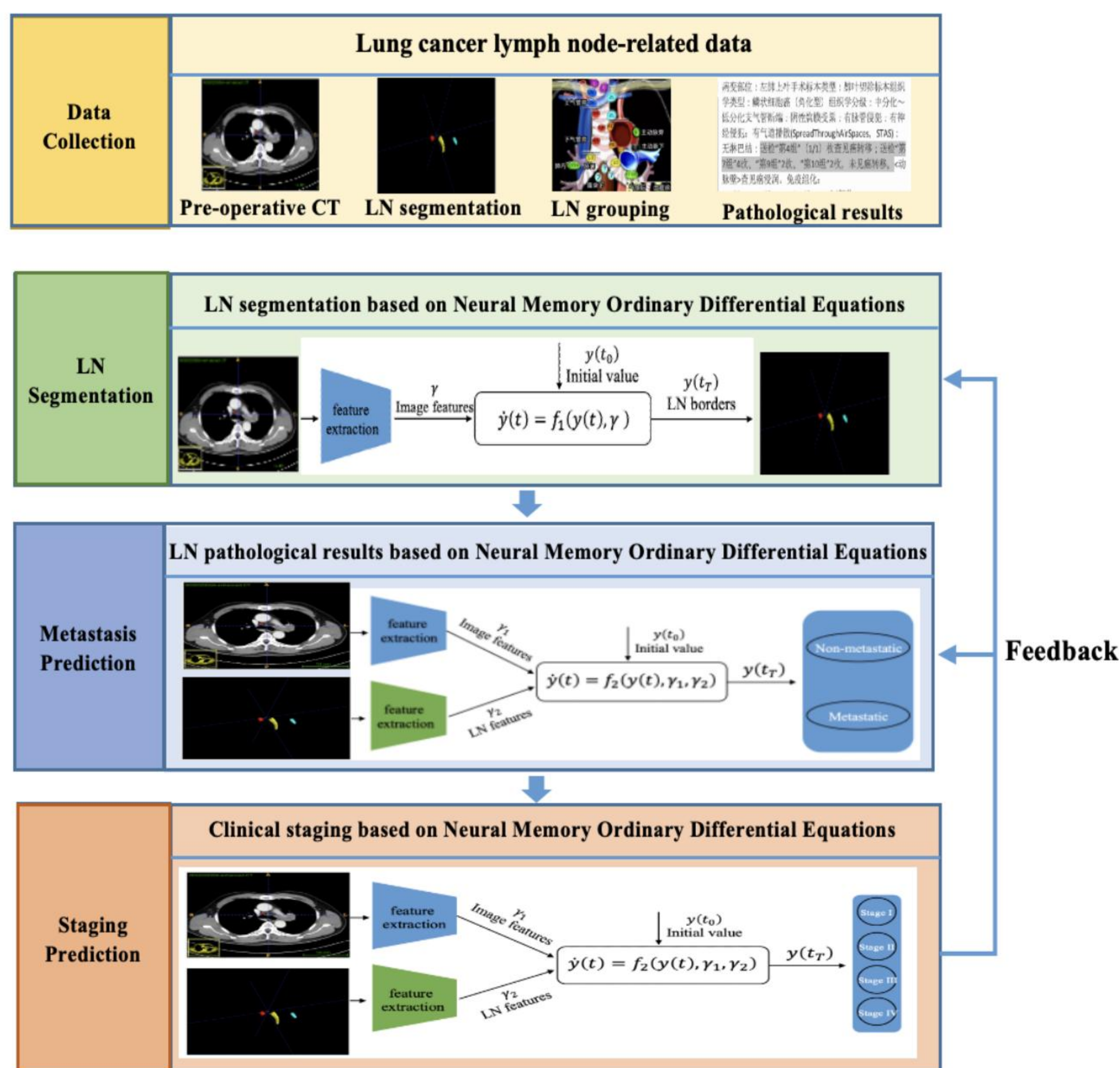
Single-stage U-Net achieved:

DSC = 0.2564 (non-contrast)

DSC = 0.2731 (contrast-enhanced)

Relative improvement: ~76.4% (non-contrast) and ~72.2% (contrast-enhanced) over baseline.

Key observation: Performance consistently higher on contrast-enhanced scans, indicating added discriminative value.



RESULTS

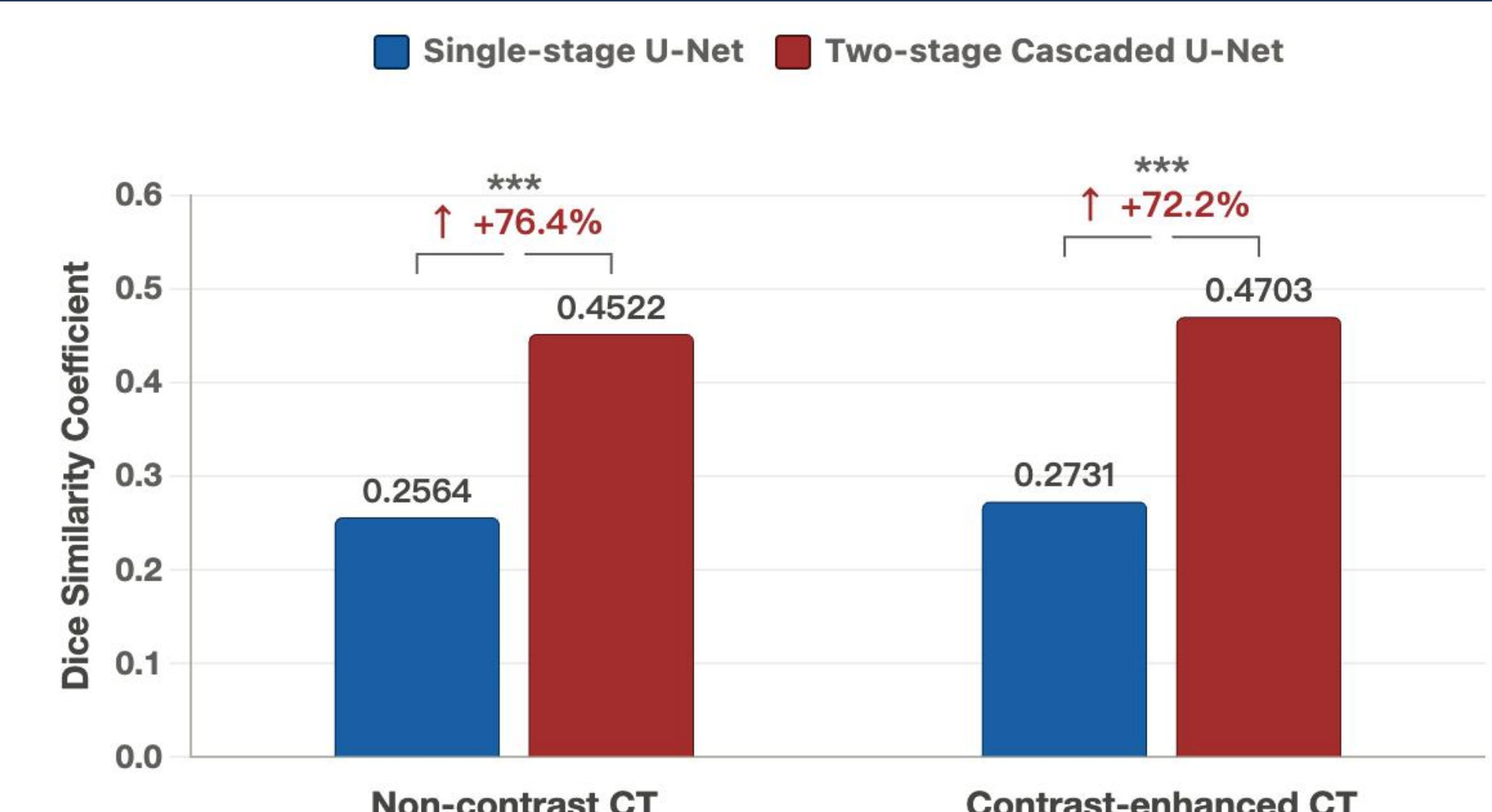


Figure. Comparison of Dice similarity coefficients between single-stage U-Net and two-stage cascaded U-Net on non-contrast and contrast-enhanced CT. Asterisks (***) indicate significant improvement of the two-stage model over the single-stage model (+76.4% and +72.2%, respectively).

DISCUSSION AND CONCLUSION

- Our two-stage cascaded U-Net significantly outperforms the single-stage baseline, achieving Dice scores of 0.470 vs. 0.273 on contrast-enhanced CT (relative improvement >72%).
- The coarse-to-fine strategy effectively captures small, low-contrast lymph nodes that are often missed by standard models.
- Performance is consistently higher on contrast-enhanced CT, indicating that vascular enhancement provides critical discriminative features for accurate segmentation.
- This model serves as a foundational AI tool for non-invasive nodal assessment, with potential to reduce unnecessary invasive biopsies such as EBUS or mediastinoscopy.
- For clinical integration, we recommend using contrast-enhanced CT as the preferred input and deploying the model as a “second reader” to auto-delineate nodal boundaries and flag high-risk nodes for multidisciplinary review.
- Future work includes multicenter external validation, upgrading segmentation to metastasis risk classification, and combining with primary tumor and distant metastasis models for comprehensive TNM staging assistance.