A Combined Deployable End-to-end Automated AI Detection and Quantitative Visualization Pipeline for Hemothorax on Admission Trauma CT

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Introduction

Internal hemorrhage in the non-compressible torso is the leading reversible traumatic cause of death. Hemothorax (HTX) benefits from prompt diagnosis and quantitative visualization (QV). Volumes correlate with hemorrhage related outcomes. SOC methods rely on subjective radiologist assessment and WBCT interpretation times increase with injury severity. We address the unmet need for a DICOM/PACS-interoperable automated detection and precision diagnostics tool.

Hypothesis

Our approach will have high accuracy metrics and DSC in highly imbalanced in-the-wild data.

Methods

8,157 CT consecutive cases from our trauma center included 838 HTX-positive and 7,319 HTX-negative cases. The dataset comprised 2,468,327 slices (64,570 w/ HTX). All cases underwent rigorous voxelwise human-in-loop labeling with multi-reader arbitration and systematic bias mitigation protocols. Our two-stage approach consisted of: 1) slice-level detection (SException) and focal loss for imbalanced data, with Embedding-Vision Transformer (E-VIT) for patient-level aggregation and 2) MedNeXt for QV. The model was trained on 8 H100 GPUs. Temporal validation set included 3,194 studies.

Results

We achieved 0.98 AUROC, 86.3% sensitivity, 91.2% specificity, 97.8% NPV, 59.9% precision, 70.8% F1-score and 0.79 DSC, with high HTX saliency. Lower performance was observed for small, less clinically significant HTX. Mean inference times were 27.6 seconds for detection, with preprocessing and feature extraction for E-VIT as the main computational bottleneck, and 81.2 seconds for segmentation.

Conclusion

Our method demonstrates high accuracy and overlap metrics in a temporal validation set with in-the-wild distribution. The approach provides the first quantitative, explainable detection/QV tool for HTX, aligning with established quantitative

laboratory and vital sign standards in surgical care. The system's enterprise-ready orchestrator enables seamless clinical integration through low-latency pop-ups and IM alerts, DICOM SEG visualization, and automated volumetric reporting. Future work will focus on multicenter validation, bias analysis, and correlation with clinical outcomes.

Figure(s)

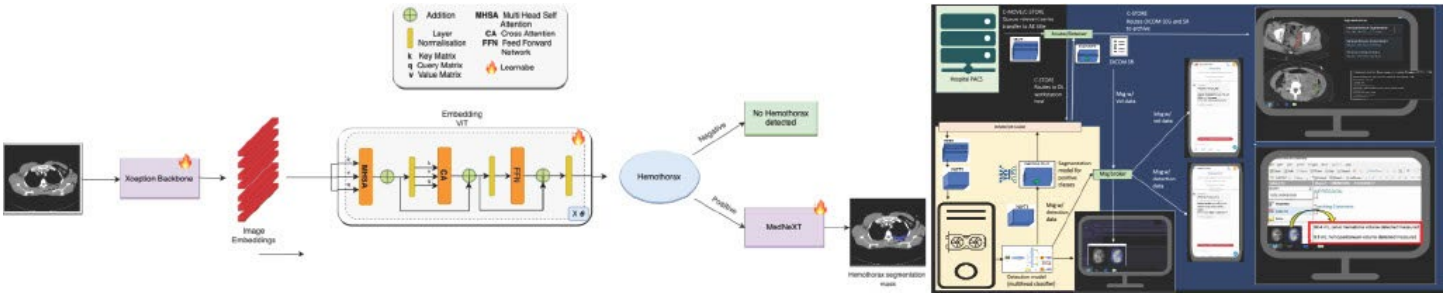

Figure 1a. combined detection-segmentation pipeline (left), **Figure 1b.** example of orchestrator for other detected pathology (presented at SIIM 2024) (right)

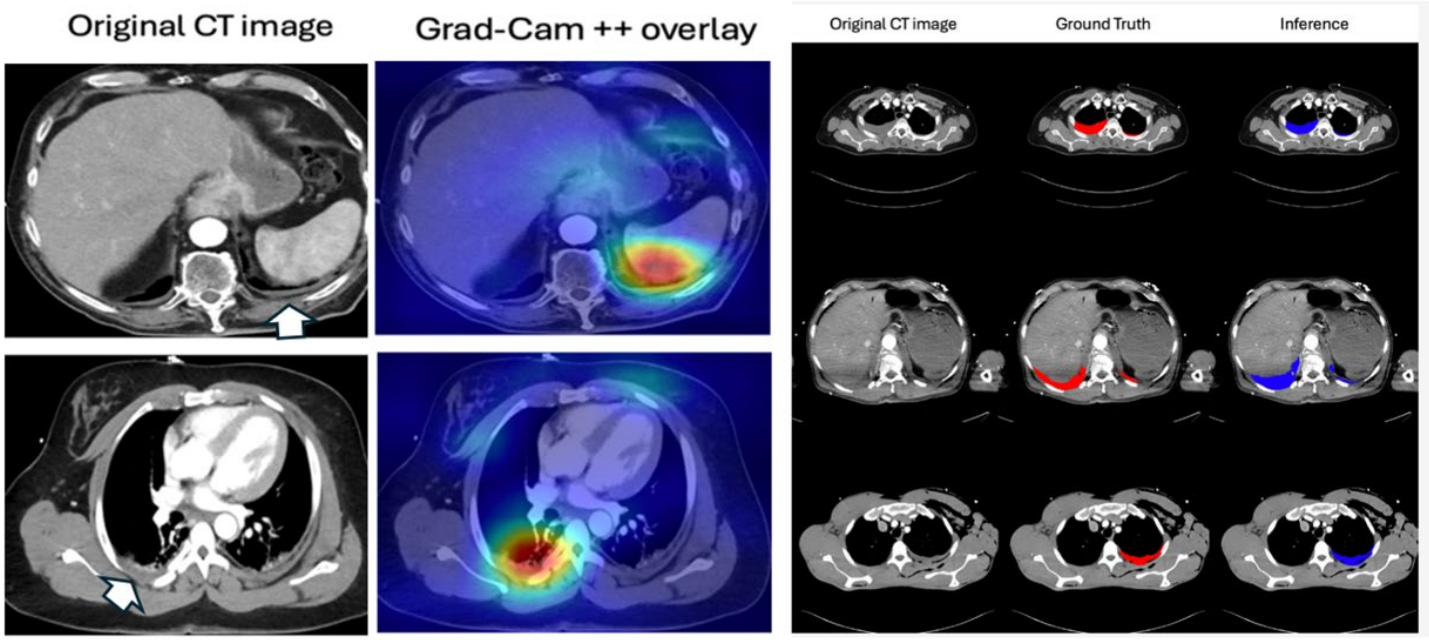

Figure 2a. TP detection saliency maps in challenging low-volume studies— note, study in bottom column detects some subpulmonic HTX above spleen (left), **Figure 2b.** high-saliency explainable MedNeXt segmentation. QV is performed by orchestrator using voxel counting from DICOM SEG object metadata (right).

Keywords

Applications; Artificial Intelligence/Machine Learning; Clinical Workflow & Productivity; Imaging Research; Quality Improvement & Quality Assurance