Enhancing Lung Cancer Screening Through a Novel Deep Learning-Powered Software for Automated Lung Nodule Detection, Segmentation, Analysis, and 3D Modeling in CT Scans

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Lung cancer is the leading cause of cancer-related mortality worldwide, largely due to diagnosis at advanced stages when treatment is limited. Although low-dose computed tomography (LDCT) screening in high-risk individuals enables early detection, limitations remain including high false-positive rates, radiologist workload, and the difficulty of annotating and evaluating lung nodules within complex thoracic anatomy. This study presents a novel, fully automated deep learning-powered software for computationally efficient lung nodule detection, segmentation, analysis, and 3D modeling in chest CT scans. A multi-stage pipeline producing a nodule segmentation mask was developed, consisting of three components: a residual convolutional neural network for high-sensitivity candidate generation, a convolutional encoder-decoder network for pixel-level nodule segmentation, and an XGBoost classifier for false positive reduction. All models were trained and validated using 586 preprocessed CT scans with multi-radiologist annotations. On a held-out test set of 20 scans, the pipeline achieved a detection sensitivity of 0.971, a Dice coefficient (measures segmentation overlap with radiologists) of 0.802, an average of 0.6 false positives per scan, and an average runtime of 18.247 seconds per scan. The framework was implemented in an application that processes a raw CT scan and outputs a tri-planar viewer with all nodules annotated as well as per-nodule radiological statistics and interactive 3D meshes derived from the segmentation output. By functioning as a rapid and cost-effective preliminary reader in radiology workflows, the software can improve LDCT screening accuracy while reducing diagnostic turnaround time, facilitating earlier cancer detections and improved patient outcomes.

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