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Scientific Article

Deep Learning Approaches for Lung Cancer Classification Using Computed Tomography: A Comparative Review

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Abstract

Lung cancer remains one of the leading causes of cancer-related mortality worldwide. Early and accurate diagnosis is critical for improving patient outcomes. Computed Tomography (CT) has become a primary imaging modality for lung cancer screening. In recent years, deep learning methods have shown strong potential for automated lung cancer detection and classification. This review examines recent advances in deep learning-based approaches for lung cancer classification using CT imaging. We focus on convolutional neural networks, vision transformer models, and hybrid architectures that combine both approaches. The strengths and limitations of each approach are discussed based on reported performance metrics and methodological design. This review aims to provide a structured overview for researchers and clinicians seeking to understand current trends and challenges in AI driven lung cancer diagnosis.

Keywords

Lung cancer, computed tomography, deep learning, convolutional neural networks, vision transformers, medical image analysis

1. Introduction

Lung cancer is one of the most common cancers. It is also one of the deadliest worldwide. The American Cancer Society reports about 1.8 million lung cancer deaths each year. Lung cancer remains the leading cause of cancer related death globally (Siegel et al., 2024). Early detection improves survival. Many cases are still found late as early disease often has no symptoms. CT has become the primary imaging modality for lung cancer screening and diagnosis due to its high spatial resolution and sensitivity. Large scale screening programs, such as the National Lung Screening Trial, have demonstrated that low-dose CT can significantly reduce lung cancer mortality (Aberle et al., 2011). However, manual interpretation of CT scans is time consuming and subject to interobserver variability.

Artificial intelligence (AI), particularly deep learning, has emerged as a powerful tool to assist radiologists in interpreting medical images. Deep learning models can automatically learn discriminative features from large volumes of imaging data. It helps in accurate classification and detection of lung abnormalities. Over the past decade several deep learning architectures have been proposed for lung cancer analysis, including convolutional neural networks (CNNs), vision transformers (ViTs), and hybrid models.

This review summarizes these approaches. We focus on the method, the reported results, and clinical relevance. The goal is to help clinicians and researchers understand AI for lung cancer diagnosis.

2. Literature Search Strategy

A structured literature search was conducted. The following search query was used:

("lung cancer" OR "lung nodule") AND ("computed tomography" OR "CT") AND ("deep learning" OR "convolutional neural network" OR "vision transformer" OR "hybrid model")

Studies were included if they met the following criteria: Focused on lung cancer or lung nodule classification using CT images, Employed deep learning-based methods, Reported quantitative evaluation metrics and Published in peer-reviewed journals.

Studies focused exclusively on segmentation or non-imaging data were excluded.

3. Deep Learning Approaches for Lung Cancer Classification

3.1 Convolutional Neural Networks

Convolutional neural networks have been widely adopted for lung cancer classification due to their ability to learn hierarchical spatial features. Early studies demonstrated that CNNs could outperform traditional machine learning approaches based on handcrafted features.

Setio et al. (2017) evaluated multiple CNN architectures on the LUNA16 dataset and reported strong performance in distinguishing malignant from benign pulmonary nodules. Similarly, Shen et al. (2017) employed multi-scale CNNs to capture nodules of varying sizes, achieving improved classification accuracy. Ardila et al. (2019) further demonstrated that deep CNNs trained on large-scale CT datasets could achieve performance comparable to expert radiologists. However, CNNs may struggle to capture information in complex anatomical structures.

3.2 Vision Transformer Models

Vision transformers use self-attention to learn patterns across the entire image. Unlike CNNs, transformers process images as sequences of patches. Dosovitskiy et al. (2021) introduced the Vision Transformer, which demonstrated competitive performance with convolutional models when trained on large datasets. Later studies applied transformers to lung CT and reported improved classification performance (Tang et al., 2022). However, transformer-based models often require large annotated datasets and substantial computational resources, which can limit their applicability in clinical settings.

3.3 Hybrid CNN Transformer Models

Hybrid models use CNN layers for feature extraction and transformer blocks to combine information across the image. These models aim to overcome the limitations of purely convolutional or transformer-based approaches. Recent studies have shown that hybrid architectures outperform standalone CNNs and transformers in lung cancer classification tasks. Li et al. (2023) demonstrated that hybrid CNN transformer networks achieved higher accuracy and better generalization across multiple datasets, suggesting their suitability for complex medical imaging tasks.

Table 1. Comprehensive summary of various studies focused on lung classification

Reference	Model Type	Dataset	Task	Performance
Setio et al., 2017	CNN	LUNA16	Nodule classification	AUC = 0.89
Shen et al., 2017	CNN	LIDC-IDRI	Nodule classification	Accuracy = 85–87%
Ardila et al., 2019	CNN	NLST CT	Lung cancer screening	AUC = 0.94
Dosovitskiy et al., 2021	Vision Transformer	ImageNet (transfer)	Image classification	Competitive accuracy
Tang et al., 2022	Transformer	Lung CT	Cancer classification	AUC = 0.92
Li et al., 2023	Hybrid CNN Transformer	Multicenter CT	Lung cancer classification	AUC = 0.94

4. Discussion and Conclusion

The reviewed studies demonstrate that deep learning has significantly advanced lung cancer classification from CT imaging. CNN based models remain strong performers, particularly when training data are limited. Vision transformers offer improved modeling but require larger datasets and computational resources. Hybrid approaches combine the strengths of both architectures and often achieve superior performance. Despite these advances challenges remain. Model generalizability across institutions, data heterogeneity, and limited explainability continue to hinder clinical adoption. Deep learning has transformed lung cancer image analysis by enabling accurate and automated classification from CT scans. While convolutional neural networks remain a strong foundation, transformer-based and hybrid architectures offer promising improvements. Continued research focusing on interpretability, robustness, and clinical validation will be essential for translating these methods into routine clinical practice. Future work should improve robustness across populations and validate models in prospective clinical studies.

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