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A Symptom-Aware Deep Learning Model for Lung Cancer Detection Using Sparse Channel Attention and Sequential CT Analysis

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Abstract: ***Lung cancer detection is challenging due to late diagnosis, complex CT image patterns, and limitations in existing deep learning models such as sensitivity to noise, redundant feature extraction, and lack of clinical context. To address these issues, this study proposes a symptom-aware deep learning framework that integrates ASNS-Net for adaptive noise suppression, SCAS-Net for efficient feature selection, and MVC-BLDNet (CNN with Bi-LSTM) for capturing both spatial and inter-slice sequential features. By incorporating patient symptom information and advanced attention mechanisms, the model enhances feature representation and reduces false predictions. The framework also improves computational efficiency by eliminating irrelevant features and focusing on diagnostically significant regions. Furthermore, the integration of sequential learning enables better understanding of tumour progression across CT slices. Overall, the proposed approach improves accuracy, robustness, and generalization, making it effective for early and reliable lung cancer detection and supporting clinical decision-making.***

Keywords: ***Lung cancer detection using CT imaging with deep learning, symptom-aware modelling, and sparse channel attention. Incorporates CNN, BiLSTM, and Explainable AI for accurate and early diagnosis.***

I. INTRODUCTION

Lung cancer is one of the leading causes of cancer-related mortality worldwide, mainly due to difficulties in early detection and accurate diagnosis. Medical imaging techniques, particularly Computed Tomography (CT), play a crucial role in identifying lung abnormalities and detecting tumor growth at an early stage. In recent years, deep learning methods, especially Convolutional Neural Networks (CNNs), have shown significant potential in computer-aided lung cancer diagnosis. However, existing models often face challenges such as image noise, redundant feature extraction, and the lack of integration of clinical information, which can reduce diagnostic performance. To address these limitations, this study proposes a symptom-aware deep learning framework that integrates adaptive noise suppression, sparse channel attention, and sequential CT analysis. Patient symptom information is utilized to guide the noise suppression process and highlight diagnostically important regions in CT images. Furthermore, a multi-view CNN combined with a Bidirectional Long Short-Term Memory (Bi- LSTM) network is used to capture spatial features and inter-slice dependencies across sequential CT scans, aiming to improve detection accuracy, robustness, and reliability in computer-aided lung cancer diagosis.

II. LITERATURE REVIEW

Author/Year	Title	Techniques Used	Limitations
Uddin, Jia (2024)	Attention-based DenseNet for Lung Cancer Classification Using CT scan and Histopathological Images	DenseNet architecture integrated with attention mechanisms to improve feature extraction from CT and histopathological images for lung cancer classification	Requires large annotated datasets; computational complexity is high; limited generalization across different imaging modalities

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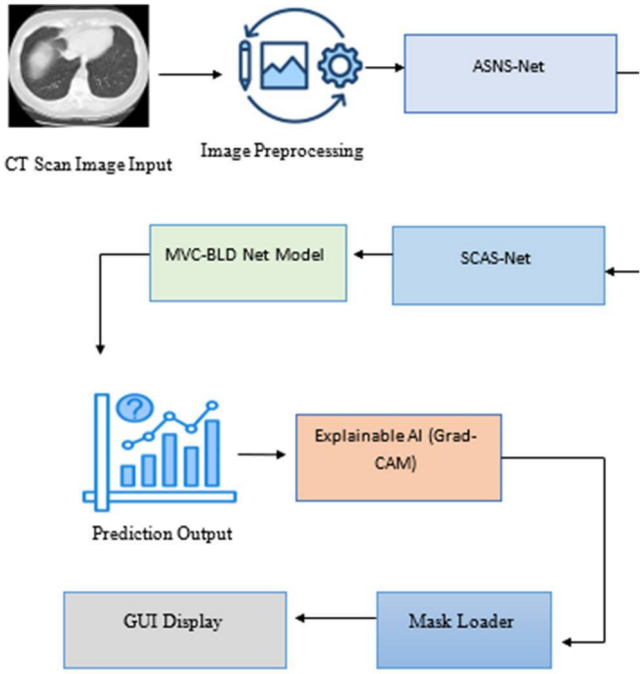
Haque, Fariha et al. (2025)	An End-to-End Concatenated CNN Attention Model for the Classification of Lung Cancer with XAI Techniques	Concatenated CNN model with attention layers and Explainable AI (XAI) techniques for interpretable lung cancer classification	Increased model complexity; interpretability methods increase computational overhead; performance depends on dataset quality
Wang, Guotai et al. (2021)	Semi-Supervised Segmentation of Radiation-Induced Pulmonary Fibrosis from Lung CT Scans with Multi-Scale Guided Dense Attention	Semi-supervised learning with multi-scale guided dense attention networks for segmentation of lung fibrosis regions in CT images	Focuses mainly on fibrosis segmentation rather than direct cancer classification; requires careful parameter tuning
Said, Yahia et al. (2023)	Medical Image Segmentation for Lung Cancer Diagnosis Based on Deep Learning Architectures	Deep learning architectures such as CNN and segmentation models for identifying lung tumor regions in medical images	Segmentation accuracy depends on image quality; limited ability to capture temporal dependencies across CT slices
Li, Yongbin et al. (2025)	Lung Nodule Detection Using a Multi-Scale CNN and Global Channel Spatial Attention Mechanisms	Multi-scale CNN with global channel-spatial attention mechanism for detecting lung nodules from CT images	May produce false positives for small nodules; high computational cost due to multi-scale processing
Deepa, J. et al. (2025)	A Novel Lung Cancer Diagnosis Model Using Hybrid Convolution (2D/3D)-Based Adaptive DenseUNet with Attention Mechanism	Hybrid 2D/3D convolution-based DenseUNet with attention mechanisms for improved lung cancer diagnosis	High memory consumption due to 3D convolutions; increased training time and hardware requirements

III. PROPOSED SYSTEM

The proposed system introduces a symptom-aware deep learning framework for lung cancer detection using CT scan images, designed to improve early diagnosis and reduce false detection. The framework consists of three major modules: Adaptive Symptom-Aware Noise Suppression Network (ASNS-Net), Sparse Channel Attention Selection Network (SCAS-Net), and Multi-View CNN with Bi-Directional Long Short-Term Memory Network (MVC-BLDNet).

Initially, ASNS-Net performs preprocessing by suppressing imaging noise while preserving important lesion boundaries using symptom-guided attention mechanisms. The enhanced images are then processed by SCAS-Net, which performs deep feature extraction and applies sparse channel attention to select tumor-relevant features while removing redundant information, thereby reducing computational complexity.

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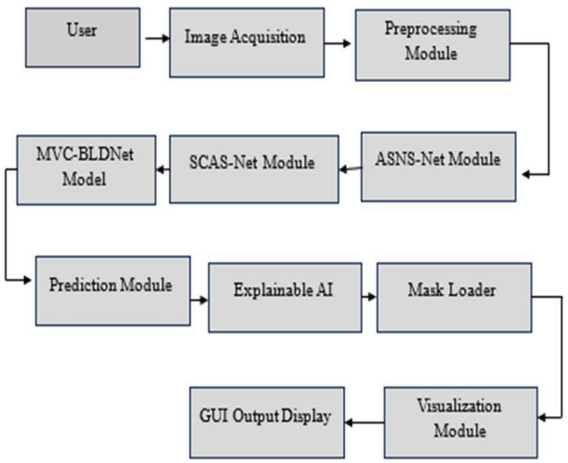
Finally, the MVC-BLDNet model analyzes the selected features by combining multi-view CNN for spatial feature extraction and Bi-directional LSTM for capturing sequential inter-slice dependencies in volumetric CT scans. This integrated framework improves feature representation, enhances robustness, and increases lung cancer detection accuracy, making it suitable for reliable computer-aided diagnosis and early clinical decision support.

IV. SYSTEM ARCHITECTURE

The system architecture defines the complete workflow and interaction of modules in the lung cancer detection system, starting from CT image acquisition to final prediction. It includes preprocessing steps such as resizing, normalization, and noise removal to enhance image quality for better analysis.

Advanced deep learning modules like ASNS-Net, SCAS-Net, and MVC-BLDNet are used for image enhancement, feature selection, and accurate classification by capturing both spatial and sequential features. Explainable AI techniques such as Grad-CAM further highlight important tumour regions to improve transparency.

Additionally, the system incorporates a mask loader for validation and provides prediction results with confidence scores. All functionalities are integrated into a user-friendly GUI, enabling efficient visualization, interaction, and reliable medical diagnosis.



V. RESULT &ANALYSIS

The results of the proposed lung cancer detection system demonstrate high accuracy and reliability in classifying CT scan images as cancerous or normal. The model effectively extracts important features and provides predictions along with confidence scores, enabling quick and accurate diagnosis. Visualization techniques such as Grad-CAM heatmaps highlight tumour regions, helping users understand the model's decision-making process.

The analysis shows that integrating deep learning models with Explainable AI improves both performance and transparency. The system reduces manual effort for radiologists and supports early detection of lung cancer. Additionally, the comparison with ground truth masks validates the accuracy of tumour localization, making the system suitable for real-world medical applications.

VI. CONCLUSION

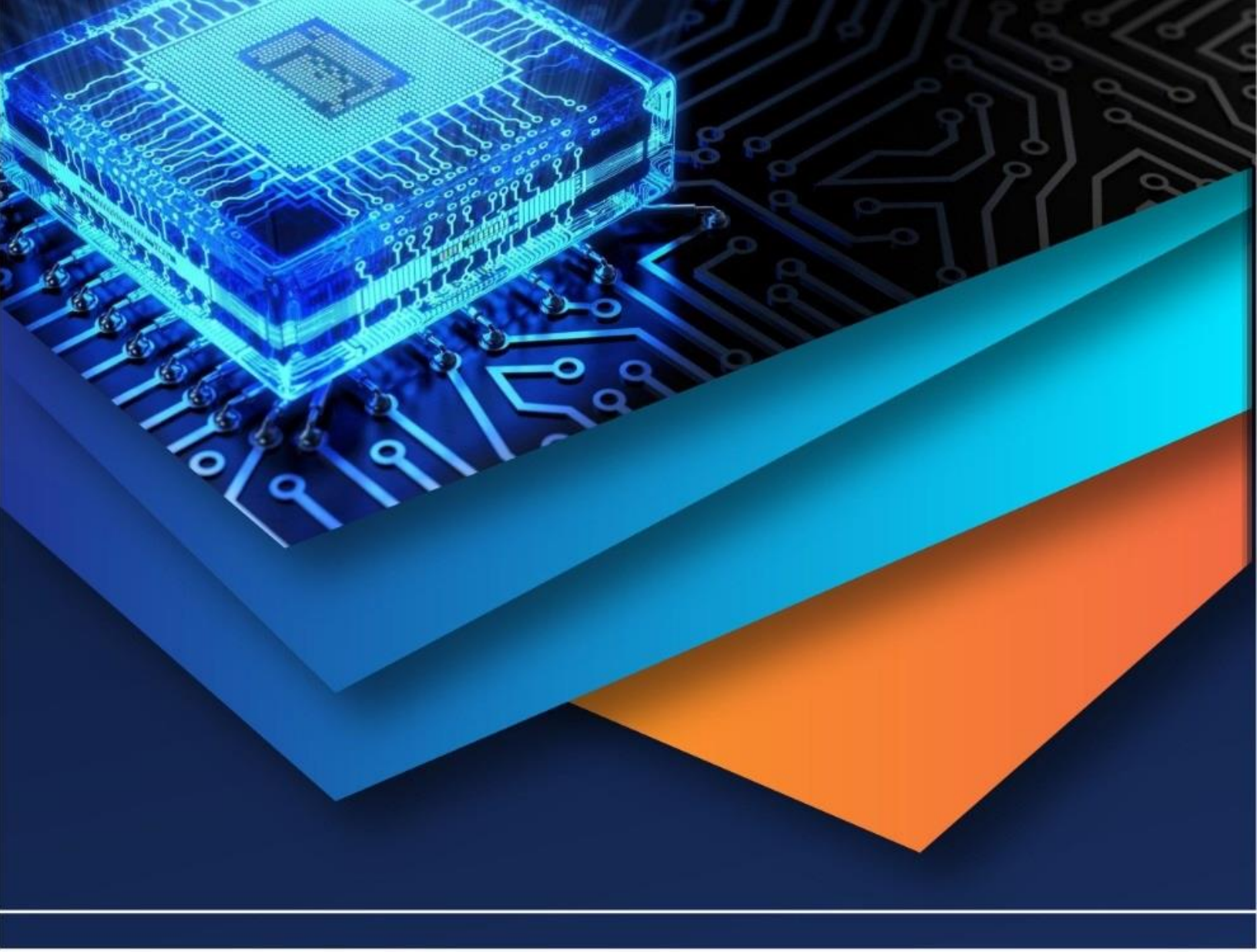
The proposed lung cancer detection system successfully integrates advanced deep learning techniques to provide accurate and efficient diagnosis using CT scan images. By combining models such as ASNS-Net, SCAS-Net, and MVC-BLDNet, the system effectively enhances image quality, extracts meaningful features, and performs reliable classification of cancerous and normal cases. The inclusion of Explainable AI techniques like Grad-CAM improves transparency by highlighting important regions influencing the prediction, making the system more trustworthy for medical professionals. The user-friendly GUI further enhances usability by allowing easy image upload, visualization of results, and comparison with ground truth masks.

Overall, the system demonstrates strong performance in terms of accuracy, reliability, and interpretability, making it a valuable tool for early lung cancer detection. It has the potential to assist radiologists in clinical decision-making and contribute to improved patient outcomes through timely diagnosis.

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