Pakistan Journal of Multidisciplinary Innovation (PJMI)

ISSN Print: 2957-501X
ISSN Online: 2957-5028
Volume 5, Number 1, 2026, Pages 01 – 11
Journal Home Page
https://journals.airsd.org/index.php/pjmi

Comparative Analysis of State of the Art Deep Learning Models for Lung Cancer Detection

Sana Nisar Shaikh[1], Allah Bachayo Brohi[2] &Saba Nisar Shaikh[3]

[1,2]*Department of Computer Science, Government College University Hyderabad, Pakistan*
[3]*Department of Computer Science, Hyderabad Institute Technology Management Science*

ARTICLE INFO

Article History:

Received:	*October*	*03, 2025*
Revised:	*December*	*13, 2025*
Accepted:	*January*	*05, 2026*
Available Online:	*January*	*17, 2026*

Keywords:

Deep Learning (DL) techniques, Convolutional Neural Network (CNN), LCP-CNN, Inception V3, EfficientNet-B3, ResNet, DenseNet, and hybrid CNN–LSTM.

ABSTRACT

This study is based on the reviews recent advancements in deep learning (DL) techniques applied to lung cancer detection from 2021 to 2025. Models such as lungs cancer prediction-Convolutional Neural Networks (LCP-CNN), Inception V3, EfficientNet-B3, and Convolutional Neural Networks Long Short-term Memory (CNN–LSTM) are achieved previous development model accuracies in between 86% and 99%, using deep learning techniques for diagnostic methods. Public datasets, including Kaggle and LIDC-IDRI, were most frequently used for train, test and validation, supporting model generalization and reliability. This Research trends show a peak in 2023 with increased use of hybrid and ensemble deep learning model integrating (CNN) and Vision Transformers (Vitis). Overall, the study concludes that deep learning based diagnostic systems significantly improve the accuracy and automation of lung cancer detection, reducing diagnostic errors and supporting early medical intervention. In this study the Convolutional Neural Network techniques has achieved the highest accuracy from other deep learning techniques.

Corresponding Author's Email: allah.bachayo@gmail.com

Introduction

The Lung cancer that is experienced today is among the most common and the deadliest cancers that has caused death to millions of people every year around the world. As World Health Organization estimates approximately one in every six cancer related deaths, it is one of the significant WHO public health diseases. Since the diagnosis of this disease is hard to cope with early diagnosis and timely treatment to improve the survival rates, the traditional diagnostic tests like X-rays, CT scan, and biopsies fail to show malignancies at a tender stage because of the indistinct imaging patterns and inter-observer variability. This has contributed to an increase in the use of artificial intelligence (AI), and deep learning (DL) to detect lung cancer in an automatic, precise and effective manner. Convolutional Neural Networks (CNNs) among other powerful deep learning frameworks have been shown to perform exceptionally well in the task of classifying medical images. Over the past five years,

researchers have applied diverse architectures such as LCP-CNN, Inception V3, EfficientNet-B3, ResNet, Dense Net, and hybrid CNN–LSTM networks to classify lung nodules, segment lesions, and predict survival outcomes. Studies have shown that these architectures achieve high accuracy rates ranging from 86% to 99%, significantly outperforming traditional image processing and machine learning approaches.

Artificial Intelligence

The Artificial intelligence (AI) of the contemporary world. It is focused on creating intelligent machines which act, think, and behave in the way human beings do. Artificial Intelligence is a term coined by John McCarthy in 1956[1] during the Dartmouth Conference defining the focal point of the AI industry. Nowadays, it has become part of the computer industry. The work of artificial intelligence is highly scientific and developed. The most important issues in artificial intelligence are the challenges in producing machines to execute such functionality like problem-solving, skills in thinking, organizing, speech recognition, and reasoning. Some of the the fields that are familiar as subfields of artificial intelligence include software computing, computer learning, computational modeling, optical character identification. The Artificial Intelligence (AI) technical holidays the path towards computers being able to reason like human beings. The Machine Learning (ML) in order to form the way more level with training and learning aspects. The light to deep learning concept is made available by the availability of massive dataset, high-performance computers, giving the deep learning concept the ability to extract automatically the factors of variation or features that make objects different to each other.

Literature Review

The literature review reveals consistent progress in deep learning-based lung cancer detection. For instance, Heuvel Mans et al. The U.S. and European datasets of (2021) tested the LCP-CNN model and reported 99% sensitivity and unnecessary scans minimization. Thamilarasi and Roselin (2021) performed CNNs using the JSRT dataset with an 86.67 percent accuracy in the classification of chest X-rays. Recent changes include the work of Maren Takis et al. (2021) with radiomics and LSTM Long Short-Term Memory Inception models to classify histology and Doppalapudi et al. (2021) with ANN, CNN and RNN to predict survival with 71.18 per cent accuracy. Hybrid and ensemble architectures have also demonstrated almost perfect performance in the last few years. In their study, Obayya et al. (2023) combined the Tuna Swarm Algorithm with the deep learning to achieve a high accuracy of 99.33 on image-based prediction with CT scans of the LIDC dataset, whereas Nafea et al. (2023)
used the EfficientNet-B3, which performed multi-class studies with varying accuracy on the same dataset (4). Moreover, Ozdemir et al. (2025) ensemble CNNs with Vision Transformers (ViTs) to reach 99.54% accuracy and emphasize the opportunities of attention-improved hybrid models to be used in clinical environments. On the whole, these articles prove the fact that deep learning and the use of biomedical imaging may provide one of the methods in the lung cancer diagnosis. The enhanced accuracy in various architectures attests to the efficiency of an automated diagnostic system to detect malignancies at the initial stages prelude to the minimization of mortality and assist oncologists with precision medicine. This research, thus, aims at designing, validating and evaluating a deep learning-based system to early identify lung cancer in CT and X-rays scan and prioritize on optimization of performance, comparative analysis, and interpretability

SNO	Reference	Methodology	Dataset	Accuracy	Summary
1	[2]	The LCP-CNN	US NLST	99.0 %	This paper confirmed Deep Learning model (LCP-CNN) data trained on the U.S data on lung cancer prediction with European datasets with an AUC of 94.5%. It correctly excluded 22.1% of benign nodules with a sensitivity of 99% to unneeded follow-up scans.
2	[3]	CNN	JSRT	86.67%	The proposed CNN-based method automatically classifies chest X-ray images as normal or abnormal, achieving 86.67% accuracy and faster diagnosis using the JSRT dataset.
3	[4]	SVM KNN	NSCLC radiomics	74%	In this paper, a CT image of NSCLC is classified into adenocarcinoma and squamous cell carcinoma with the highest accuracy of 74% and the best diagnostic tool compared to expert radiologists, at the LSTM + Inception model.
4	[5]	(ANN),(CNN), and (RNN)	National Cancer Institute in the United States	71.18 %	It employs the deep learning models (ANN, CNN, and RNN) to estimate the survival of lung cancer patients and its prediction accuracy (71.18) and error are greater, which can be considered a baseline of improving early prognosis.
5	[6]	BICLCD-TSADL	Kaggle	99.33%	The suggested BICLCD-TSADL model combines deep learning and Tuna Swarm Algorithm to identify and classify colon and lung cancers effectively with high rates of accuracy and robustness in the analysis of biomedical images.
6	[7]	Inception V3 Random Forest	Kaggle	97.09%	Common deep learning algorithms used for lung cancer detection include Convolutional Neural Networks (CNN), Inception V3, and Random Forest. These models are trained on

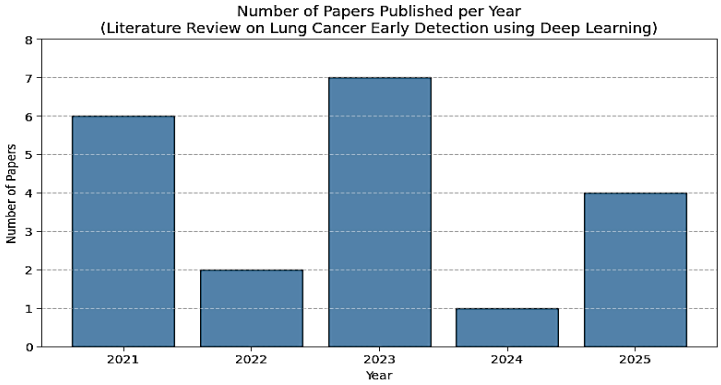
					histopathological lung cancer tissue images to improve detection accuracy and efficiency.
7	[8]	Deep learning algorithm using Efficient Net B3	Lung Image Database Consortium (LIDC) dataset. LIDC / IDR dataset Kaggle	96%	This study addresses the global impact of lung cancer and emphasizes the importance of early detection. It proposes a deep learning model based on Efficient Net B3 to classify four types of lung cancer—Normal, Squamous cell carcinoma, large cell carcinoma, and Adenocarcinoma—using CT scan images. The model had an accuracy of 96 percent that was an improvement of 2.13 percent, compared to the earlier classifiers. These findings demonstrate a high possibility of deep neural networks as the results of the research indicate a high potential to improve early lung cancer diagnostics, increase the quality of detection, and help clinicians make better decisions, which benefits patients.
8	[7]	3D-CNN	LUNA 16 database	95%	It presents a Hybrid Neural Network (CCDCHNN) based on 3D-CNN to identify early and accurate lung cancer based on CT scan and have better accuracy in differentiating between benign and malignant tumors.
9	[9]	CNN, CNN-GD, VGG-16, VGG-19, Inception V3, and ResNet-50	CT scan images and Histopathological images.	97.86%.	This paper shows a step forward in the detection of lung cancer through six deep learning networks (CNN- GD VGG-16, and VGG-19 and Inception V3, and ResNet-50) and demonstrates better accuracy, particularly on cases of lung cancer detected via histopathology images as opposed to CT images.
10	[10]	2DNN	LUNA 16	95%	

11	2021	3D CNN	LUNA16	94.8%	A 3D CNN combined with U-Net segmentation detected nodules in volumetric CT data, improving spatial context awareness.
12	[11]	CNN	Public medical imaging	99%	In this paper, deep learning, and in this case, CNN-based models such as Dense Net and Reset are used to distinguish the severity of lung cancer with the highest accuracy of 99% indicating that there is significant promise of early detection and better diagnosis as compared to traditional methods.
13	[12]	model combining CNNs and Vision Transformers (ViTs)	IQ-OTH/NCCD dataset	99.54%	In this work, a hybrid model of deep learning based on CNNs and Vision Transformer (ViTs) will be presented to improve the CT-based diagnosis of lung cancer. Combining the Inception Next blocks with grid and block attention blocks, the model is capable of capturing the multi-scale and contextual features as it allows the accurate classification of the malignant, benign, and specific cancer subtypes. It was trained on matrices of Chest CT and IQ-OTH/NCCD data, and on both, the accuracy of its results was up to 98.41 and 99.54, respectively, which is better than the current techniques. This is a promising light but powerful model that has high potential of clinical use in detection of early lung cancer.
14	[13]	CNN RNN	Kaggle	98.5%	In this paper, an LCRP model based on X-ray and CT images is suggested to differentiate between diseases of the lungs, lung cancer being one of them. It is a combination of preprocessing, augmentation, segmentation, and prediction

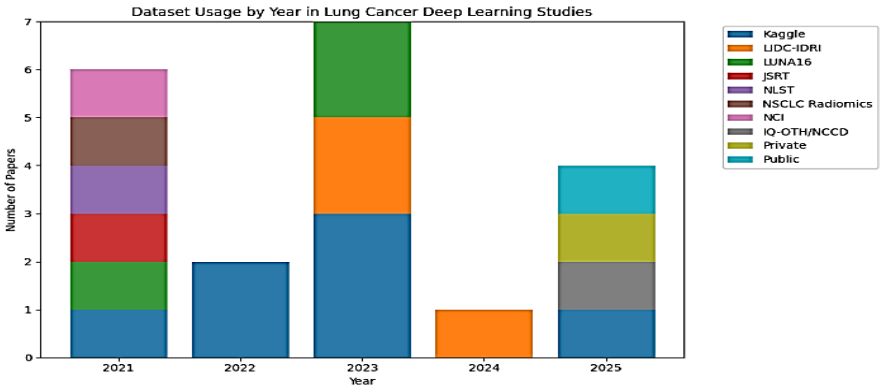
					modules, which are combined with CNNs and mask R-CNN with accuracy of 98.5% and high specificity and sensitivity. The dual optimizer method improves output and frees up less computation which is better than current pre-trained networks.
15	2022	CNN + LSTM	Kaggle Lung CT Dataset	95.7%	Spatial features were captured by CNN system and sequences of slices were captured by LSTM system; it works in the early stages.
16	2023	Ensemble (ResNet + DenseNet	LIDC-IDRI + Private	98.1%	An ensemble of several CNNs with weights minimized the variance and boosted the generalization.
17	2025	Quantum CNN	Private clinical dataset	95.2%	Added inbuilt quantum inspired layers to improve exploration of feature space.
18	[15]	CNN	Kaggle	90.2%	In this paper, the author gives a CNN technique development that can predict lung cancer in CT scans with high accuracy and proves its applicability in improving the computer-aided diagnosis and early detection of the disease.
19	[16]	CNN	IDRI) (LIDC-IDRI)	90.9%	In this research, it is suggested to detect lung cancer in its early stages through CNN-based deep learning tools on the LIDC-IDRI datasets with a maximum accuracy of up to 100 percent when using a single batch of the data in a training algorithm. The method is especially more efficient and faster than SVM and previous models in classifications.
					using Lung image database consortium (LIDC)-image database resource initiative (IDRI) (LIDC-IDRI) data set and revealed that they could

					get classification accuracy of 90.9% for 33 CT images with specificity of 94.74%.
20	[17]	CNN	Kaggle	0.7%	This study introduces DFD-Net, a two-path CNN that first denoises CT images using DR-Net before detecting lung cancer, effectively integrating local and global features to handle nodule variability and improve diagnostic accuracy.

Discussion



In this research the graph represents the distribution of research papers reviewed from 2021 to 2025 related to lung cancer detection through deep learning techniques. In 2021, a total of 6 research papers were reviewed. This indicates that during this year, significant research was carried out focusing on the early application of CNN and ANN models for lung cancer diagnosis. In 2022, the number of reviewed papers decreased to 2, suggesting relatively less research activity or fewer published works in this specific domain. The year 2023 had the highest number of reviewed studies as seven papers were reviewed, indicating a rapid rise in the research on the detection of early lung cancer. These papers primarily concerned the new model architectures such as Efficient Net, hybrid CNN-LSTM systems, and ensemble-based. Comparatively, the number of 2024 articles reviewed dropped significantly, one article only, which could possibly mean that there is a momentary decline in the amount of work published or insufficient data on that year. As of 2025, four papers were reviewed, which indicates the returned interest in detecting lung cancer with the purpose of enhancing accuracy by combining hybrid CNN-based models.



Dataset Usage Patterns in Deep Learning-based Lung Cancer A dataset usage patterns study 2021 to 2025 illustrates the dataset usage patterns of different research studies that developed deep learning models and validated them using the publicly and privately available datasets. Researchers used a very broad set of data in 2021 in Kaggle, LUNA16, JSRT, NLST, NSCLC Radiomics, and NCI that showed various experimentation and comparison of different sources of images. The variety of the datasets used throughout this year demonstrates the attempts by scientists to measure the generalization skills across the resolutions and data types. The and narrower research focus was in 2022 with the prevailing dataset coming as Kaggle. This trend implies a bias towards easy-to-use and human-labeled datasets to train CNN-based models. As of 2023, the largest amount of data has been available, with Kaggle, LIDC-IDRI, and LUNA16 datasets having a high degree of use. Such interest is indicative of the increased accessibility to standardized medical image databases, as well as the adoption of large-scale databases which allow more precise and generalizable deep learning models. In 2024, the usage of datasets was minimal with only the usage of LIDC-IDRI as the data usage constitute the panel of reduced research output in publication trends. However, in 2025, it again saw new growth in usage of datasets, with Kaggle, IQ-OTH/NCCD, Private, and public data being added. This variety suggests an increased focus on the idea of open-source and proprietary clinical data integration to strengthen the model and increase its applicability in the real world. Generally, the analysis establishes that Kaggle and LIDC-IDRI have continued to be used and trusted most during the five years period. The fact that they are dominant highlights their appropriateness in medical image analysis based on deep learning as they have large size, high quality and detailed annotations.

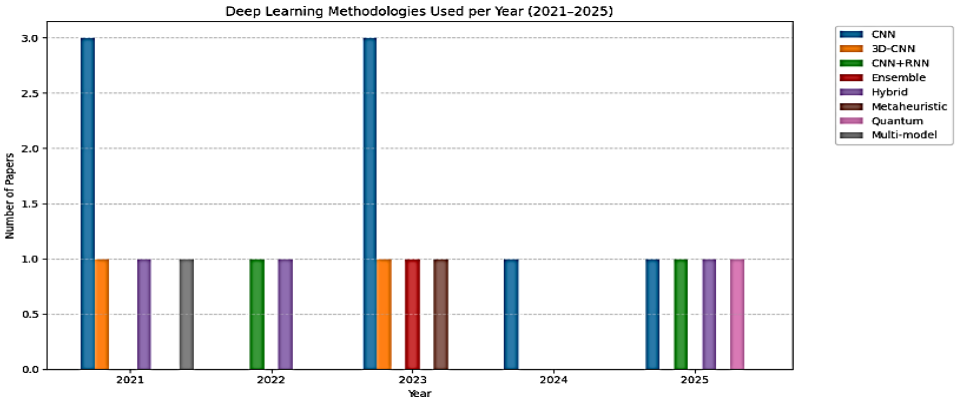


Figure: Deep Learning Methodologies Used per Year (2021–2025)

The bar chart is used to show how the deep learning methodologies are distributed in the research publications between 2021 and 2025. The most common method was convolutional Neural Networks (CNNs), which reached significant spikes in 2021 and 2023 both, with three articles per year. Other approaches, including 3D-CNN, CNN with Recurrent Neural Networks (CNN+RNN), Ensemble, Hybrid, Metaheuristic, Quantum, and Multi-model seemed to have less impressive numbers, just one publication per year. Loss of methodological diversity is noted in the year 2024 though with a minor recovery in 2025 especially with Hybrid and Quantum models. All in all, the data indicate a tendency towards the use of CNN-based architectures during the analysed period but the emerging and hybrid techniques. demonstrate intermittent but growing interest in recent years.

Model	**Accuracy**
The LCP-CNN	99.0 %
CNN	86.67%
SVM and KNN	74%

(ANN), (CNN), and (RNN)	71.18 %
BICLCD-TSADL	99.33%
Inception V3	97.09%
Random Forest	
Efficient Net B3	96%
3D-CNN	95%
CNN, CNN-GD, VGG-16, VGG-19, Inception V3, and ResNet-50	97.86%.
2DNN	95%
3D CNN	94.8%
CNN	99%
CNNs and (ViTs) to enhance CT-based lung cancer diagnosis.	99.54%
CNN RNN	98.5%
CNN + LSTM	95.7%
Ensemble (ResNet + DenseNet	98.1%
Private clinical dataset	95.2%

The comparative study of deep learning and machine learning models on lung cancer detection indicated the accuracy of 71.18% to 99.54%. The CNN- Vision Transformer (ViT) hybrid model (99.54 percent) dominated with a very close second meaning that hybrid and task-specific structures are effective. Traditional CNN-based models have produced high-quality results (86-99per), and more advanced models, like EfficientNet-B3 (96per), 3D-CNN (94.8-95per), and ensemble models, like ResNet + DenseNet (98.1per) have added to the quality of the metrics. Conversely, the standard ML algorithms (KNN 74% and SVM) had lower performance. On the whole, the results show that deep learning, especially the use of hybrids and transformers, has significantly better outcomes as compared to traditional methods, as it is more accurate and reliable to identify lung cancer manually.

Conclusion

The comparative study of deep learning and machine learning models on lung cancer detection indicated the accuracy of 71.18% to 99.54%. The CNN- Vision Transformer (ViT) hybrid model (99.54 percent) dominated with a very close second meaning that hybrid and task-specific structures are effective. Traditional CNN-based models have produced high-quality results (86-99per), and more advanced models, like EfficientNet-B3 (96per), 3D-CNN (94.8-95per), and ensemble models, like ResNet + DenseNet (98.1per) have added to the quality of the metrics. Conversely, the standard ML algorithms (KNN 74% and SVM) had lower performance. On the whole, the results show that deep learning, especially the use of hybrids and transformers, has significantly better outcomes as compared to traditional methods, as it is more accurate and reliable to identify lung cancer manually.

Future Work

When using deep learning (DL) in detecting lung cancer, there are multiple challenges that leave opportunities to further studies. Future research should aim at elaborating explainable and interpretable DL models to improve clinical trust and decision transparency so that the

healthcare professionals could have a clearer understanding of the model predictions. Incorporating multi- modal data, such as CT, PET, and histopathological images, as well as genomic and clinical data may help to improve diagnostic strength and individual treatment more.

References

[1] G. Chassagnon *et al.*, "Clinical utilization and future outlook of artificial intelligence techniques in lung oncology," *Japanese Journal of Radiology*, vol. 41, no. 3, pp. 235–244, 2023, doi: 10.1007/s11604-022-01359-x.

[2] M. A. Heuvelmans *et al.*, "Deep learning–based assessment of pulmonary nodules for distinguishing malignant and non-malignant cases," *Lung Cancer*, vol. 154, pp. 1–4, 2021, doi: 10.1016/j.lungcan.2021.01.027.

[3] V. Thamilarasi and R. Roselin, "Convolutional neural network–driven categorization of lung abnormalities in chest radiographic images," *IOP Conference Series: Materials Science and Engineering*, vol. 1055, no. 1, Art. no. 012099, 2021, doi: 10.1088/1757-899x/1055/1/012099.

[4] P. Marentakis *et al.*, "Radiomics-assisted deep learning framework for histopathological subtype recognition of lung cancer from CT data," *Medical & Biological Engineering & Computing*, vol. 59, no. 1, pp. 215–226, 2021, doi: 10.1007/s11517-020-02302-w.

[5] S. Doppalapudi, R. G. Qiu, and Y. Badr, "Interpretable deep neural models for estimating survival duration in lung cancer patients," *International Journal of Medical Informatics*, vol. 148, Art. no. 104371, 2021, doi: 10.1016/j.ijmedinf.2020.104371.

[6] M. Obayya *et al.*, "Hybrid deep learning and tuna swarm optimization for automated colon and lung cancer image analysis," *IEEE Access*, vol. 11, pp. 94705–94712, 2023, doi: 10.1109/ACCESS.2023.3309711.

[7] S. Wankhade and V. S., "An integrated neural network–based deep learning architecture for early-stage lung cancer identification," *Healthcare Analytics*, vol. 3, Art. no. 100195, 2023, doi: 10.1016/j.health.2023.100195.

[8] M. S. Ibrahim *et al.*, "EfficientNet-B3–oriented deep learning strategy for automated lung cancer recognition," 2023, doi: 10.31185/wjcms.209.

[9] V. Rajasekar *et al.*, "Deep feature extraction from CT and histopathological imagery for predictive modeling of lung cancer," *Results in Engineering*, vol. 18, 2023, doi: 10.1016/j.rineng.2023.101111.

[10] A. A. Shah *et al.*, "Ensemble two-dimensional convolutional neural networks for computerized lung cancer diagnosis," *Scientific Reports*, vol. 13, no. 1, pp. 1–15, 2023, doi: 10.1038/s41598-023-29656-z.

[11] M. Faseeh-ur-Rehman, R. Ali, and M. Fuzail, "Deep learning–based prognostic modeling for lung carcinoma outcome estimation," vol. 6, no. 6, pp. 265–274, 2025.

[12] B. Ozdemir, E. Aslan, and I. Pacal, "Attention-augmented InceptionNeXt hybrid network for enhanced lung cancer detection," *IEEE Access*, vol. 13, pp. 27050–27069, 2025, doi: 10.1109/ACCESS.2025.3539122.

[13] M. A. Tawfeek *et al.*, "Optimized CT-driven lung cancer screening through predictive deep learning models," *Neural Computing and Applications*, vol. 37, no. 17, pp. 11459–11477, 2025, doi: 10.1007/s00521-025-11084-x.

[14] Y. Jiang *et al.*, "Comparative evaluation of deep learning models for lung cancer risk estimation using NLST cohort data," *Scientific Reports*, vol. 15, no. 1, pp. 1–12, 2025, doi: 10.1038/s41598-024-84193-7.

[15] L. Gadikota, "Application of convolutional neural networks for lung cancer risk prediction," pp. 1–14, 2023.

[16] S. Jamdar *et al.*, "Automated identification and categorization of lung cancer using deep neural learning techniques," *IAES International Journal of Artificial Intelligence*, vol. 13, no. 1, pp. 1119–1128, 2024, doi: 10.11591/ijai.v13.i1.pp1119-1128.
[17] J. Feng *et al.*, "DFD-Net: deep learning-based lung cancer detection from noise-suppressed CT imagery," vol. 15, no. 2, 2021.