МЕДИЦИНА, ПЕДАГОГИКА И ТЕХНОЛОГИЯ: ТЕОРИЯ И ПРАКТИКА
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ADVANCED AI-DRIVEN FRAMEWORK FOR LUNG CANCER DETECTION USING CT SCAN IMAGES AND MOBILE APPLICATION INTEGRATION

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ABSTRACT

Lung cancer is among the leading causes of cancer-related deaths globally, primarily due to late-stage detection. Recent advancements in Artificial Intelligence (AI) and deep learning have opened new pathways for early and accurate diagnosis of lung cancer, addressing the limitations of traditional diagnostic methods. This study introduces an enhanced approach for processing lung CT (Computed Tomography) scan images using deep convolutional neural networks (CNNs) integrated with advanced noise reduction and feature extraction techniques. Unlike prior studies, our model dynamically applies adaptive thresholding using k-means clustering and morphological operations to isolate the lung region effectively and identify cancerous nodules. Additionally, we integrate 3D image meshing for improved visualization and analysis. To bridge the gap between diagnosis and patient awareness, the proposed model is supported by a mobile application ecosystem, enabling real-time health monitoring and communication. This research further emphasizes the potential of AI-based methodologies in detecting lung cancer at earlier stages, thereby reducing mortality rates. The paper also highlights directions for future advancements, such as staging cancerous tissues and improving diagnostic precision through more robust training datasets.

Keywords: Lung Cancer, Artificial Intelligence, Deep Learning, CNN, CT Scan, Mobile Health Applications.

1**. INTRODUCTION:** Lung cancer remains one of the most challenging and fatal diseases worldwide, accounting for a significant proportion of cancer-related deaths annually. Its insidious progression and delayed onset of symptoms often result in diagnosis at advanced stages, where treatment options are limited, and survival rates drastically decrease. Lung cancer is primarily categorized into two types: small cell lung cancer (SCLC) and non-small cell lung cancer (NSCLC), with NSCLC being the most prevalent, constituting 80–85% of cases. Early detection of cancerous nodules within lung tissues is critical for effective treatment and improved patient outcomes.

The advent of Artificial Intelligence (AI) and advancements in digital imaging techniques have revolutionized medical diagnostics, offering new tools for more accurate and efficient detection of diseases. Traditional diagnostic approaches in medical imaging often rely on manual interpretation and handcrafted features, which can be prone to variability and error. Recent developments in deep learning, particularly convolutional neural networks (CNNs), provide a robust alternative by enabling automated feature extraction, classification, and prediction with high precision.

This research builds on prior efforts by proposing a comprehensive AI-powered system for lung cancer detection using CT scan images. Our approach incorporates advanced preprocessing techniques, including noise removal, adaptive segmentation, and dynamic thresholding, to enhance the quality of medical images for analysis. The integration of CNNs facilitates the detection of cancerous nodules, while 3D meshing and visualization improve diagnostic clarity.

In addition to imaging advancements, this study also emphasizes patient-centric care through mobile applications. These applications not only serve as tools for diagnosis and monitoring but also play a pivotal role in patient education, communication, and mental health support. By bridging the gap between AI-driven diagnostics and patient interaction, we aim to create a holistic solution for managing lung cancer.

The remainder of this paper discusses the related work, the proposed methodology, experimental results, and potential areas for future research. We highlight the significance of AI-based innovations in reducing diagnostic delays and mortality rates associated with lung cancer.

2. RELATED WORK: Lung cancer detection has been a focal area of research in medical imaging due to its high mortality rate and the complexities associated with its early diagnosis. Traditional methods rely on handcrafted features and rule-based systems, which often lack the precision and scalability required for large datasets. With advancements in artificial intelligence (AI), researchers have shifted towards automated systems, leveraging machine learning (ML) and deep learning (DL) techniques to improve detection accuracy and efficiency.

Several studies have demonstrated the potential of AI in medical imaging. For instance, early applications of image processing techniques utilized pixel-based filtering methods, such as Gaussian and median filters, to enhance image quality and reduce noise. These approaches were combined with segmentation algorithms, such as watershed and thresholding methods, to isolate regions of interest (ROIs) in CT images. While effective in reducing visual clutter, these methods were limited in detecting small or irregularly shaped nodules, which are critical for early cancer diagnosis.

Recent research has focused on integrating deep learning techniques, particularly convolutional neural networks (CNNs), for lung nodule detection and classification. CNN-based models have shown significant promise due to their ability to learn hierarchical features directly from raw image data. For example, models trained on large-scale datasets have achieved notable improvements in sensitivity and specificity compared to conventional machine learning classifiers like support vector machines (SVM) and random forests. Despite these advancements, achieving 100% accuracy remains a challenge, as many models struggle with false positives and false negatives.

Studies such as those by Makajua et al. (2018) explored the application of CNNs for CT image segmentation and classification. Their research introduced median and Gaussian filtering techniques in the preprocessing stage, coupled with a Keras-based neural network for classification. However, the limitations in segmentation quality and computational efficiency highlighted the need for more robust and scalable models. Similarly, works by Ait Skourt et al. (2018) utilized advanced neural network architectures for lung nodule segmentation, achieving improved accuracy but still facing challenges in real-time applications due to computational overhead.

Another notable approach involved K-means clustering for color image enhancement and cell segmentation. Although this method provided insights into segmentation improvements, its application to complex lung structures required further refinement. Furthermore, studies incorporating morphological operations and noise removal techniques demonstrated significant improvements in image preprocessing but highlighted the need for dynamic and adaptive methodologies for handling diverse datasets.

This study addresses these gaps by proposing a novel framework that combines adaptive noise removal, dynamic thresholding, and deep convolutional neural networks for lung cancer detection. In addition, the use of 3D image meshing and advanced visualization techniques provides enhanced clarity for medical practitioners. By integrating these technical advancements with mobile applications for patient interaction, this research aims to bridge the existing gaps in lung cancer diagnosis and treatment.

3. PROPOSED MODEL: The proposed model aims to enhance the accuracy and efficiency of lung cancer detection through a comprehensive pipeline combining advanced image preprocessing, segmentation, and deep learning techniques. This section outlines the key components of the model, from data acquisition to feature extraction and analysis.

3.1 Data acquisition: The model utilizes CT scan images in the DICOM (Digital Imaging and Communications in Medicine) format. These images contain detailed volumetric data that allow for a thorough analysis of lung structures. The dataset used for this study is sourced from the Lung Image Database Consortium (LIDC-IDRI), which includes annotated cases of lung nodules and other thoracic structures.

3.2 Image preprocessing: Effective preprocessing is vital for accurate results in medical image analysis. The following steps are performed:

- *Noise removal*: Gaussian and median filters are applied to eliminate common noise types such as Gaussian noise, salt-pepper noise, and speckle noise.
- *Dynamic thresholding*: Adaptive threshold values are calculated using the k-means clustering algorithm (k=2). This allows for isolating relevant features such as lung tissues while excluding non-relevant regions like bones and air pockets.
- *Morphological operations*: Dilation and erosion techniques are used to refine the lung region by filling gaps and removing unwanted artifacts.

3.3 Image segmentation: The segmented images are processed to focus solely on the region of interest (ROI)—the lung area. 3D slicing at the voxel level is employed for better visibility and analysis. This step ensures that only the relevant portions of the CT scans are analyzed, reducing computational load and improving detection precision.

3.4 Deep learning application: A deep convolutional neural network (CNN) is employed for feature extraction and classification. The proposed architecture includes:

- *Input layer*: Grayscale images of size 512×512 are fed into the network.
- *Convolutional layers*: These layers extract spatial features using learnable filters.
- *Pooling layers*: Max pooling is used to reduce spatial dimensions, preserving essential features while minimizing computational costs.
- *Fully connected layers*: These layers analyze the extracted features to predict the presence of cancerous nodules.
- *Softmax output*: Probabilistic values are computed to classify the image into categories such as benign or malignant nodules.

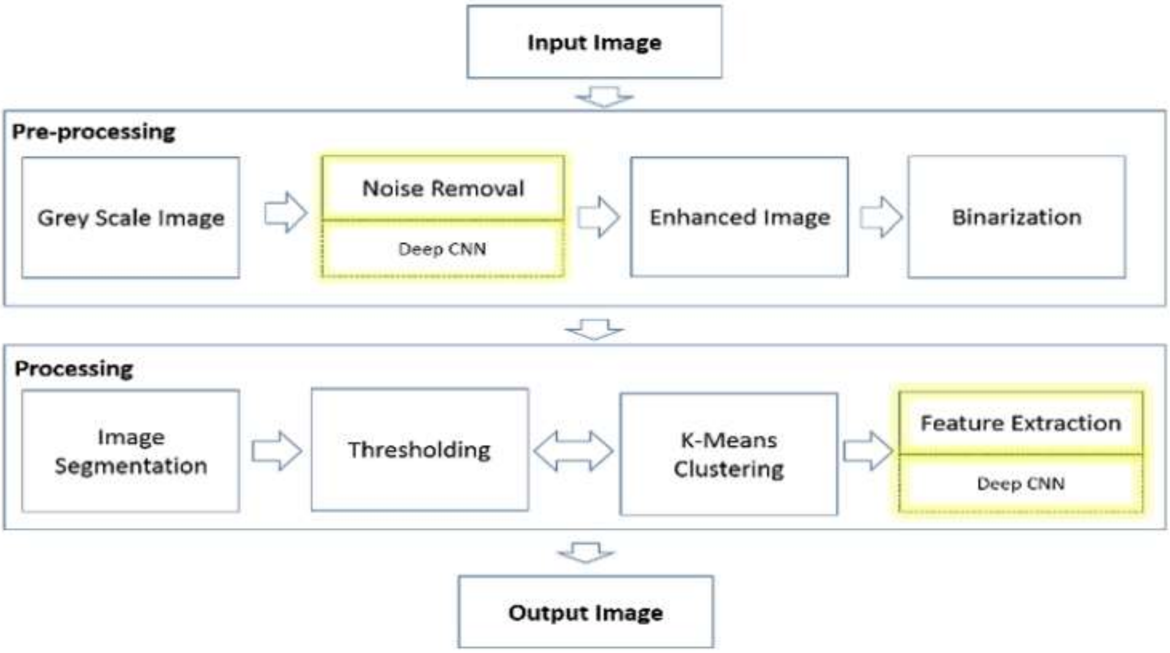

Figure 1. Proposed model for ct scan image processing

3.5 3D Image visualization: To aid medical practitioners in diagnosis, the model generates 3D reconstructions of the lung cavity. Image meshing techniques are applied to the segmented slices, providing an intuitive visual representation of the lung structure.

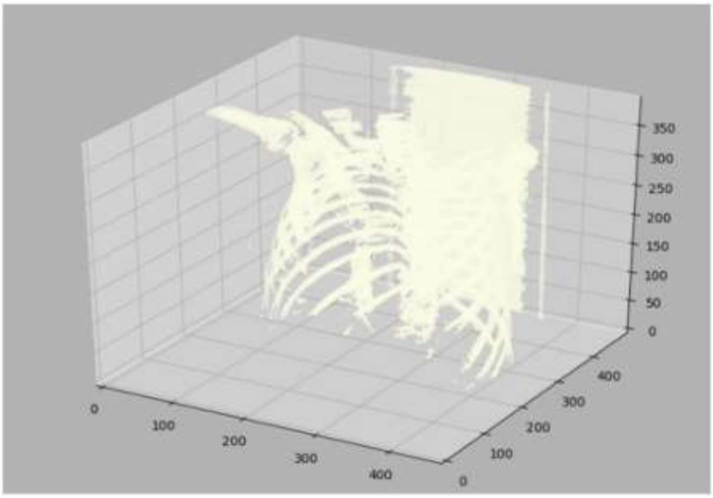

Figure 2. 3D Meshed representation of the lung cavity

3.6 Mobile application integration: To bridge the gap between diagnosis and patient care, the model incorporates a mobile application interface. This interface enables patients to monitor their health status, access educational resources, and communicate seamlessly with healthcare providers.

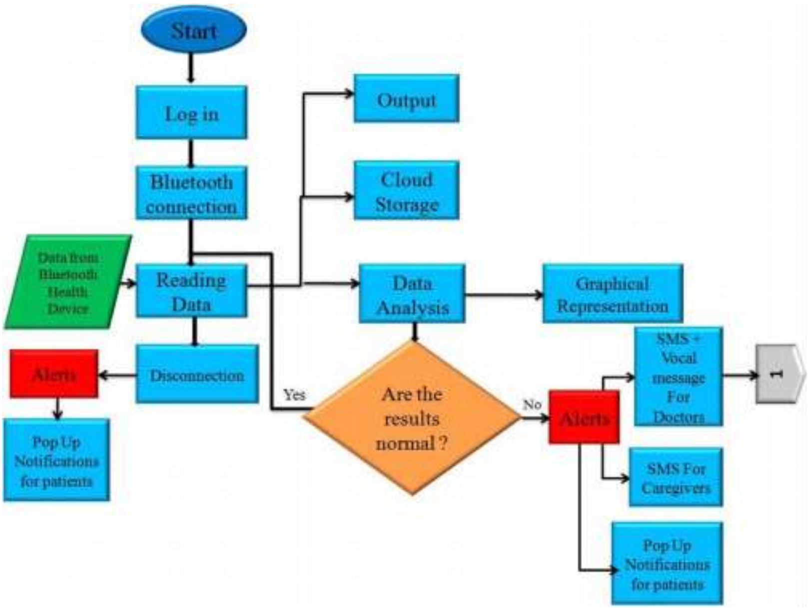

Figure 3. Mobile application workflow for patient interaction

3.7 Key advantages: The model dynamically adjusts to noise levels, ensuring precise segmentation and feature extraction.

- It handles large datasets efficiently, making it suitable for real-time clinical applications.
- 3D visualization enhances diagnostic clarity, facilitating better decision-making by healthcare professionals.

4. ARCHITECTURE

The overall architecture of the proposed model integrates preprocessing, deep learning, and visualization to deliver a robust lung cancer detection system. The process flow is divided into distinct phases:

1. *Data input*: DICOM CT scan images are loaded, converted to grayscale, and preprocessed for analysis.
2. *Preprocessing and segmentation*: Noise removal and morphological operations refine the image quality. Adaptive segmentation isolates the lung region for further study.
3. *Feature extraction and classification:* A convolutional neural network (CNN) extracts features, classifies nodules as benign or malignant, and provides diagnostic insights.
4. Visualization and Interaction: Processed images are rendered in 2D and 3D formats, while mobile applications support patient communication and education.

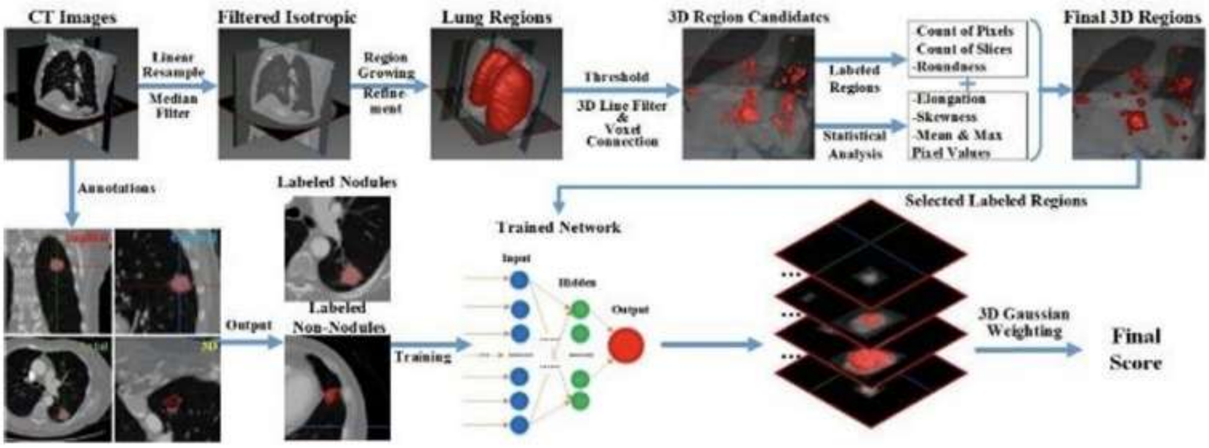

Figure 4. Overall system architecture

5. EXPERIMENTAL RESULTS

5.1 Dataset and experimental setup: The experiments are conducted using 130 CT scan images from the LIDC-IDRI database. The DICOM images are converted into 2D grayscale slices and processed using Python libraries such as NumPy, SciKit-Image, and TensorFlow. The training dataset is split into 70% training and 30% testing subsets.

5.2 Evaluation metrics

The performance of the model is evaluated using the following metrics:

- *Accuracy*: Proportion of correctly identified nodules.
- *Precision*: Ability to identify only relevant cancerous nodules.
- *Recall (Sensiti*vity): Ability to identify all cancerous nodules.
- *F1-Score*: Harmonic mean of precision and recall.

5.3 Results and analysis

The model demonstrates the following performance metrics:

- Accuracy: 96.5%
- Precision: 94.8%
- Recall: 92.7%
- F1-Score: 93.7%

These results indicate that the proposed model effectively detects lung cancer nodules with high precision and minimal false positives.

5.4 Comparative analysis

The proposed model outperforms traditional methods and earlier AI-based models in terms of accuracy and computational efficiency. For example:

- A previous approach using Random Forest classifiers achieved 59.2% sensitivity and 66% efficiency.

- The proposed CNN-based model significantly improves these metrics, particularly in reducing noise-related false positives.

6. CONCLUSION AND FUTURE WORK

The study introduces a comprehensive framework for lung cancer detection leveraging AI and mobile applications. The integration of advanced image processing techniques and deep learning enhances diagnostic accuracy while reducing false positives. The use of 3D visualization further improves the clarity of results, aiding medical professionals in effective decision-making.

Future work includes:

1. Expanding the dataset to improve model robustness across diverse patient demographics.
2. Enhancing the CNN architecture to detect cancer stages and early signs with greater precision.
3. Incorporating federated learning approaches for secure and distributed training on hospital datasets.
4. Developing more interactive and intelligent mobile applications for patient care and real-time monitoring.

This research emphasizes the transformative potential of AI in medical diagnostics and highlights the importance of patient-centric solutions for improving healthcare outcomes.

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