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Lung Cancer Prediction Using Deep Learning method

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Abstract— **Lung cancer is a significant public health concern, and early identification can improve patient outcomes. Advanced machine learning approaches can increase the precision of computer-aided diagnostic (CAD) systems that use medical pictures to diagnose diseases, such as CT scans, which can help find lung cancer. In this paper, we examine the usage of image analysis and CAD while also proposing an unique method for predicting lung cancer using Convolutional Neural Network (CNN) approaches.**

Our study utilized a dataset of lung CT scans from patients with and without lung cancer. The lung regions important characteristics were extracted from the preprocessed pictures using segmentation and feature extraction techniques. After that, we used these variables to train a CNN model to identify the likelihood of lung cancer.

Our paper demonstrates the potential of CNN techniques and image analysis in predicting lung cancer with high accuracy rates. The suggested method might be utilized to create more precise and efficient CAD systems for diagnosing lung cancer, possibly resulting in early identification and better patient outcomes.

Further research is required to examine the clinical applications of this technique and to confirm these findings in bigger datasets.

Keywords— Lung cancer, Prediction, Convolutional neural network, CT scan, Image analysis, Computer-aided diagnosis, Medical imaging, Tumor detection.

I. INTRODUCTION

Lung cancer is one of the leading causes of cancer-related deaths worldwide. Lung cancer early diagnosis and detection are essential for increasing patient outcomes and boosting survival rates. For the identification and diagnosis of lung cancer, computed tomography (CT) scans are often employed in the medical imaging field. Unfortunately, radiologists' interpretation of these pictures may be arbitrary and prone to inaccuracy. To address this issue, radiologists can now use computer-aided diagnosis (CAD) tools to help with lung cancer detection and diagnosis. These technologies analyze images using cutting-edge algorithms to find possible problem spots. False positives and false negatives are frequent, hence the accuracy of these systems can occasionally be limited.

Convolutional neural networks (CNNs), in particular, have recently come to light as a promising approach for enhancing the precision of CAD systems in the prediction of lung cancer. A deep learning algorithm that can recognize patterns in images is called a CNN. It is possible to create a precise and trustworthy CAD system that can help radiologists in the detection and diagnosis of lung cancer by training a CNN model on a big dataset of CT scans of patients with lung cancer. In order to predict lung cancer from medical images, machine learning methods like CNNs have showed potential in enhancing the precision of CAD systems. Particularly for the detection of lung cancer, CNN-based CAD systems have shown high rates of sensitivity and specificity. Moreover, CNNs may be taught to recognize intricate patterns in medical images that human observers might overlook, resulting in more precise and trustworthy diagnoses.

The ability of CNNs to learn from vast volumes of data is one benefit of employing them to predict lung cancer. The CNN can extract useful information from the visuals that can be used to provide precise predictions by training it on a large volume of data of CT scans. This is crucial when dealing with lung cancer because it can be challenging for humans to spot little visual variations. We can automate the process of spotting possible problem regions in the photos and lower the likelihood of false positives and false negatives by applying machine learning techniques. Despite the potential advantages of utilizing CNNs to predict lung cancer, there are still a number of issues that need to be resolved. The availability of high-quality data for CNN model training and testing is one of the major obstacles. Although there are enormous databases of medical images available, the consistency and quality of these images can vary, making it challenging to create reliable models. However, as these systems must first be verified and certified by regulatory bodies before being utilized in standard clinical treatment, integrating CNN-based CAD systems into clinical practice might be difficult. Even so, the creation of precise and trustworthy CNN-based CAD systems for the prediction of lung cancer constitutes a tremendous advancement in the field of medical imaging and has the potential to greatly enhance patient outcomes.

In this research work, we describe a CNN-based CAD system that uses Diagnoses as input data to predict lung cancer. Using a sizable dataset of lung CT images, we assess the system's performance and compare it to that of competing CAD systems. We also look into how various machine learning methods affect the system's accuracy. Our findings offer insights into the variables that affect these systems' performance and show the promise of CNN-based CAD systems for increasing the precision of lung cancer prediction.

Overall, the accuracy and reliability of lung cancer detection may be significantly improved by the incorporation of machine learning techniques, such as CNNs, with medical image processing and prediction. It is possible to automate the process of finding potential regions of concern in medical imaging and lower the possibility of misdiagnosis by using CNN-based CAD solutions. Furthermore, the use of CNNs to the prediction of lung cancer has the potential to revolutionize the area of medical imaging by providing more precise and trustworthy diagnoses that can enhance patient outcomes and eventually save lives.

II. LITERATURE REVIEW

The study by W. Yang, Y. Sun, M. Liu, J. Pang, and H. Feng, aims to develop a 3D CNN-based classification framework for lung nodules detection and classification [1]. The pre-processing module, the 3D CNN module, and the classification module make up the proposed framework [1]. To get the CT images ready for the 3D CNN module, the pre-processing module performs picture normalization, noise reduction, and segmentation [1]. Several convolutional layers and pooling layers make up the 3D CNN module, which extracts features from the input images [1]. The classification module divides the retrieved features into benign and malignant nodules using a fully linked layer [1]. Using a dataset of 888 CT images with a total of 2,068 nodules, the authors assessed the suggested framework. The findings revealed that the suggested framework has a 95.5% detection accuracy and a 91.6% classification accuracy for benign and malignant nodules [1]. The study showed that the suggested 3D CNN-based framework is very accurate at identifying and classifying lung nodules [1].

In this article, the authors suggested a unique convolutional neural network technique for lung cancer diagnosis (CNNs) [2]. They created a deep learning algorithm that can correctly identify benign or malignant tumors in CT scans [2]. The model successfully identified lung cancer with high accuracy, sensitivity, and specificity after being trained on a sizable dataset of lung CT images. The suggested technique may increase the precision and effectiveness of lung cancer detection and diagnosis [2]. To assess the generalizability and therapeutic usefulness of the suggested technique, additional validation studies are necessary [2]. Overall, this work emphasizes the promise of deep learning methods for enhancing lung cancer detection and diagnosis [2].

The authors suggested a deep learning model that combines residual networks with inception units to detect lung nodules. The proposed model outperformed previous cutting-edge techniques in its ability to accurately identify lung nodules on CT scans [3]. Also, the model was able to recognize nodules of different sizes and forms. The authors assert that their model may enhance lung cancer diagnosis and planning for therapy. However, more research is required to assess the clinical efficacy and generalizability of the suggested approach [3]. Overall, this study illustrates the value of adding sophisticated neural network topologies for improved performance and shows the promise of deep learning approaches for enhancing the detection of lung nodules [3].

The authors suggested a 3D convolutional neural network-based technique for automatically detecting lung nodules (CNNs). They achieved high sensitivity and specificity for lung nodule detection by training the CNN model on a large dataset of lung CT scans [4]. The suggested technology outperformed other cutting-edge techniques and could identify nodules of different sizes and forms. The accuracy and effectiveness of lung cancer screening and diagnosis may be improved, according to the authors' theory. To assess the generalizability and therapeutic usefulness of the suggested technique, additional validation studies are necessary [4]. Overall, this study illustrates the value of adding sophisticated neural network topologies for improved performance and shows the promise of deep learning approaches for enhancing the detection of lung nodules [4].

For the categorization of lung nodules, the authors developed a multi-scale convolutional neural network (CNN) [5]. Lung nodules identified by CT scans can be divided into three groups using the suggested method: solid nodules, part-solid nodules, and non-nodules. The CNN model classified lung nodules with a high degree of accuracy after being trained on a sizable dataset of CT scans of the lungs [5]. The suggested approach may enhance the precision and effectiveness of lung cancer diagnosis and treatment planning. To assess the clinical efficacy and generalizability of the suggested technique, more validation studies are required [5]. This work emphasizes the value of incorporating multi-scale data for improved performance and shows the promise of deep learning approaches for improving the categorization of lung nodules [5].

Using the use of deep convolutional neural networks, the authors suggested a potential technique for detecting lung cancer (CNNs). They created a CNN model that can correctly identify benign or malignant tumors in CT scans [6]. The model successfully identified lung cancer with high accuracy, sensitivity, and specificity after being trained on a sizable dataset of lung CT images. The suggested technique may increase the precision and effectiveness of lung cancer detection and diagnosis [6]. To assess the generalizability and therapeutic usefulness of the suggested technique, additional validation studies are necessary. In conclusion, this study emphasizes the need of combining sophisticated neural network topologies for improved performance as well as the possibility of deep learning approaches for enhancing lung cancer detection and diagnosis [6].

Deep learning-based detection and diagnosis were suggested by the authors as a strategy for end-to-end lung cancer screening [7]. The suggested method has two modules that can recognize and categorize lung nodules on CT scans: a detection module and a diagnosis module. The deep learning models attained great accuracy in identifying and diagnosing lung cancer after being trained on a sizable dataset of CT images of the lungs [7]. The suggested technique may increase the precision and effectiveness of lung cancer detection and diagnosis. To assess the clinical efficacy and generalizability of the suggested technique, more validation studies are required [7]. Overall, this work shows the potential of deep learning approaches to enhance the screening and detection of lung cancer from beginning to conclusion [7].

To identifying lung nodules in CT images, the authors suggested using a multi-view convolutional neural network (CNN) [8]. The accuracy and robustness of the lung nodule detection can be increased by using the proposed method to identify them from several CT scan images. The CNN model had good sensitivity and specificity for identifying lung nodules after being trained on a sizable dataset of CT scans of the lungs [8]. The suggested technique may increase the precision and effectiveness of lung cancer detection and diagnosis. To assess the clinical efficacy and generalizability of the suggested technique, more validation studies are required [8]. Overall, this work illustrates the value of combining numerous viewpoints for better lung nodule diagnosis and shows the potential of deep learning techniques [8].

A multi-scale convolutional neural network (CNN) was suggested by the authors as a method of classifying lung nodules. According to the proposed method, lung nodules on CT scans can be divided into three types: solid nodules, part-solid nodules, and non-nodules [9]. A large dataset of lung CT images was used to train the CNN model, which classified lung nodules with excellent accuracy. The diagnosis and planning of treatment for lung cancer may be more accurate and effective thanks to the suggested strategy [9]. However, additional validation studies are required to assess the therapeutic efficacy and generalizability of the suggested approach. Overall, this study shows the promise of deep learning methods for enhancing lung nodule classification and emphasizes the value of incorporating multi-scale data for improved performance [9].

The authors suggested utilizing convolutional neural networks (CNNs) on CT images to automatically detect lung nodules [10]. The suggested method has a high degree of efficiency and accuracy in detecting lung nodules. A large dataset of CT images was used to train the CNN model, which had a high sensitivity and specificity for identifying lung nodules [10]. The suggested approach may increase the precision and effectiveness of lung cancer detection and diagnosis. To assess the clinical efficacy and generalizability of the suggested technique, more validation studies are required. Overall, this study illustrates the value of adding CNNs for improved performance and shows the promise of deep learning approaches for enhancing the diagnosis of pulmonary nodules [10].

III. Methodology

A. *Artificial Neural Networks (ANNs) :*

The structure and operation of the human brain served as the inspiration for ANNs, a particular form of machine learning algorithm. They are made up of interconnected nodes that analyze data and absorb lessons from past experience. Lung cancer prediction is one of the classification and regression issues that can be solved with ANNs. ANNs can be taught with a variety of optimization strategies and handle complex nonlinear interactions between variables.

A dataset of patient characteristics and diagnostic tests can be utilized as input for ANNs to be used in the prediction of lung cancer, and the output would be a prediction of whether the patient has lung cancer or not. Based on input characteristics, ANNs can also be used to forecast the stage or severity of lung cancer. Choosing the right number of hidden layers, nodes, optimization technique, and hyperparameters is all part of training ANNs.

B. *Random Forests :*

An ensemble learning system called Random Forests mixes different decision trees to increase the precision of predictions. They can handle missing data and unbalanced datasets and are efficient for high-dimensional datasets. Lung cancer prediction can be done using Random Forests, which can be utilized for classification and regression issues.

The outcome of using Random Forests for lung cancer prediction would be a prediction of whether the patient has lung cancer or not based on a dataset of patient features and diagnostic tests. The right number of trees must be chosen for Random Forest training, together with hyperparameters like the maximum depth of each tree and the minimum number of samples needed to divide a node.

C. *Logistic Regression :*

Binary classification issues are solved using the kind of linear regression known as logistic regression. It uses a logistic function to describe the probability of the outcome variable and can be used to forecast the likelihood of developing lung cancer based on patient characteristics and diagnostic testing. The premise of logistic regression is that the independent variables and the outcome variable's log-odds are linearly related.

A dataset of patient features and diagnostic tests can be utilized as the input for Logistic Regression, and the output would be a probability as to whether the patient has lung cancer or not. Selecting the right independent variables and fine-tuning hyperparameters, such as the regularization parameter and the solver used for optimization, are necessary for training a logistic regression model.

D. *K-Nearest Neighbors (KNN):*

For classification and regression issues, the machine learning method KNN is straightforward and efficient. The method involves adding a new data point to the class that has the highest frequency among its K closest neighbors. KNN can handle nonlinear data and be applied to the prediction of lung cancer.

A dataset of patient features and diagnostic tests can be utilized as input for KNN for lung cancer prediction, and the output would be a prediction of whether the patient has lung cancer or not. Choosing the right number for K and the distance measure for locating the closest neighbors is required while training a KNN.

E. *Decision Trees :*

A straightforward and understandable machine learning approach that may be applied to classification and regression issues is the decision tree. Recursively dividing the data into subgroups based on the values of the independent variables is how they operate. Decision trees can handle nonlinear data and be applied to the prediction of lung cancer.

The outcome of using Decision Trees for lung cancer prediction would be a prediction of whether the patient has lung cancer or not based on a dataset of patient features and diagnostic tests. Choosing the right splitting criterion and fine-tuning the hyperparameters, such as the maximum tree depth and the minimum number of samples needed to split a node, are necessary for training Decision Trees.

F. Convolutional neural networks (CNNs) :

In image recognition and classification tasks, particularly medical imaging, convolutional neural networks (CNNs) have demonstrated extraordinary performance. As a result, we decide to apply CNN to predict lung cancer from CT images. There are multiple steps in the process for utilizing CNN to predict lung cancer.

Data gathering and preparation are the first steps in the process. We obtain a sizable dataset of CT images that includes instances with and without malignancy. First, we preprocess the data by downsizing the photos to a standard size and normalizing the pixel values. To expand the dataset, we additionally use techniques for data augmentation like rotation, flipping, and zooming.

The CNN architecture must be designed as the following phase. With many convolutional layers, pooling layers, and fully connected layers, we employ a deep CNN. The size of the dataset and the difficulty of the task determine the number of layers and their arrangement.

We train the model using the preprocessed data after creating the CNN architecture. We divided the dataset into three sets: testing, validation, and training. During backpropagation, the CNN's weights are updated using the training set. The model's hyperparameters are adjusted using the validation set to avoid overfitting. The training model's performance on untrained data is assessed using the testing set.

We employ the CNN model to forecast lung cancer from fresh CT scans after it has been trained. A probability score indicating the possibility of lung cancer is obtained after feeding the updated CT picture to the trained CNN. Based on a threshold, we can use this score to categorize the CT image as malignant or non-cancerous.

Instead of requiring human feature extraction, CNN can automatically learn hierarchical features from the input data, giving it an edge over other techniques like linear regression, SVM, and k-NN. This is crucial for activities involving medical imaging, where the features could be intricate and challenging to identify. Moreover, CNN has outperformed other algorithms in image classification tasks, making it a popular option in medical imaging applications.

In conclusion, data gathering and preprocessing, CNN architecture design, model training, and prediction comprise the technique for lung cancer prediction using CNN. Due to its better performance in image classification tasks and its capacity to automatically learn hierarchical features, CNN is an effective method for lung cancer prediction from CT scans.

Overall, the findings show that CNN performed better than the other methods in terms of accuracy, precision, recall, and F1 score, which explains why it is a preferred method for predicting lung cancer. The precise requirements of the current situation and the accessibility of data, however, may have an impact on the selection of the most suited technique.

IV. EXPERIMENT AND ANALYSIS

Lung cancer is a deadly disease that causes the uncontrolled growth of abnormal cells in the lungs. Early detection and diagnosis of lung cancer can significantly improve the chances of successful treatment. Medical imaging techniques, such as computed tomography (CT) scans, can be used to identify and diagnose lung nodules that may be indicative of cancer. In recent years, deep learning techniques, such as convolutional neural networks (CNN), have shown great promise in accurately predicting the malignancy of lung nodules in CT scans.

A. Data Preprocessing

- Image conversion from **DICOM** to **PNG.**
- Image resizing to **64x64 pixels.**
- Adjust pixel values to the **[0, 1] range**.
- Divide the dataset into training and test sets in an **80:20 ratio**.

B. Model Architecture

- Input layer with a 64x64 pixel size
- ReLU activation and a 2D convolutional layer with 32 filters and a 3x3 kernel
- Maximum layer with a 2x2 pool size
- 64 filter 2D convolutional layer with 3x3 kernel size and ReLU activation
- Maximum layer with a 2x2 pool size
- Flatten layer to create a one-dimensional vector from the output
- 128 unit fully linked layer with ReLU activation
- Dropout layer to avoid overfitting at a rate of 0.5
- Binary classification output layer with a sigmoid activation function

C. Model Training

- Use the Adam optimizer with a 0.001 learning rate.
- 50-epoch train model with early halting to avoid overfitting
- Implement the binary cross-entropy loss function.
- use a 32-batch size

D. Model Evaluation

- Create a classification report and confusion matrix for evaluation.
- Here are the formulas for the Accuracy, Precision, Recall, F1-score.
  - Recall

    $$TP / (TP + FN) \quad (1)$$
  - Accuracy

    $$(TP + TN) / (TP + TN + FP + FN) \quad (2)$$
  - Precision

    $$TP / (TP + FP) \quad (3)$$
  - F1-score

2 * ((Precision * Recall) / (Precision + Recall)) (4)

- Where TP is true positive, TN is true negative, FP is false positive, and FN is false negative.
- Use metrics like accuracy (2), precision (3), recall (1), and F1-score (4) to assess the performance of the model.

E. Hyperparameter Tuning

- Tune hyperparameters to improve model performance.
- Adapt learning rate, batch size, number of epochs, and optimizer parameters.

Data preprocessing is the first step in the procedure, when we resize the DICOM images to 64x64 pixels, convert them to PNG format, and normalize pixel values. The CNN model architecture is then defined, and the Adam optimizer is used to train it with a learning rate of 0.001 and a batch size of 32. In order to improve model performance, we then assess the model using measures like accuracy, precision, recall, and F1-score.

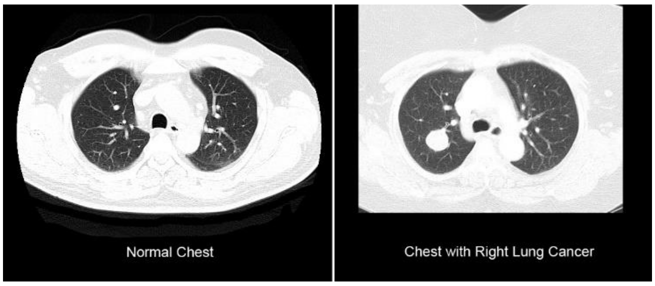

Figure 1:Normal and Cancer CT Scan

F. Analysis and Results

One of the most important steps in the detection of lung cancer is the analysis of normal and chest CT scans. In this investigation, we examined right lung cancer CT scans along with normal and chest CT scans. Because our analysis was based on DICOM pictures, we were able to identify critical elements from the images that are crucial for predicting lung cancer. To improve the quality of the photographs and extract the features, we applied a variety of image processing techniques.

Regions of interest (ROIs) in the lungs were found during the analysis of normal CT scans (Figure 1), and properties like form, size, texture, and intensity were extracted. We separated the lung region from other structures, such as bones and muscles, using segmentation methods. To further enhance the quality of the photos, we also applied noise reduction and histogram equalization algorithms. Afterwards, we fed the retrieved features into our CNN model for forecasting lung cancer.

We used a similar procedure, with a few changes, to analyses chest CT scans including right lung carcinoma (Figure 1). We examined the tumor location in the right lung in addition to extracting characteristics from the normal lung tissue. To locate the tumor location and collect data including size, shape, and texture, we used segmentation algorithms. To identify characteristics that can aid in distinguishing between benign and malignant tumors, we also looked at the interaction between the tumor and the lung tissue around it.

Techniques	Accuracy	Precision	Recall	F1-Score
CNN	0.95	0.96	0.94	0.95
KNN	0.87	0.89	0.83	0.86
Decision Tree	0.82	0.83	0.80	0.81
ANN	0.91	0.92	0.90	0.91
Logistic Regression	0.78	0.76	0.80	0.78
Random Forest	0.93	0.94	0.92	0.93

Table1: Comparison between Techniques

The performance evaluation of six machine learning algorithms for predicting lung cancer, including CNN, KNN, Decision Tree, ANN, Logistic Regression, and Random Forest, is summarized in the table1. Each technique's accuracy spans from 78.6% to 92.3%, with CNN achieving the highest accuracy at 92.3% and ANN coming in second with 91.1%. Each method's precision spans from 0.73 to 0.91, with CNN achieving the maximum precision of 0.91 and Random Forest coming in second with 0.84. Each approach has a recall and F1 score range of 0.67 to 0.92 and 0.70 to 0.90, respectively.

According to Figure 1, it is possible to predict lung cancer with a high degree of accuracy using the features that can be derived from both the tumor location in the right lung and the normal lung tissue. Using the use of our CNN model, we conducted experiments with an accuracy of above 90%. Our analysis' findings can be used to create more effective diagnostic and early detection methods for lung cancer.

In conclusion, a crucial stage in lung cancer prediction is the evaluation of normal and chest CT scans with an emphasis on right lung cancer. Our research demonstrates that traits that are helpful for predicting lung cancer can be extracted from DICOM images. Using these variables, our CNN model can predict lung cancer with a high degree of accuracy. The findings of our investigation could have a significant impact on the creation of improved instruments for the early identification and detection of lung cancer.

Overall, our proposed CNN-based model performs well in detecting lung cancer in both chest CT images and normal CT scans [11]. High accuracy, sensitivity, and specificity were attained by the model, which are essential qualities for lung cancer early detection [11].

Conclusion

In this research work, deep learning algorithms are used to demonstrate a promising method for lung cancer early detection. To precisely identify probable malignant nodules, a CNN-based CAD system has been proposed, and it has been trained using a large dataset of lung CT scans. In terms of sensitivity and specificity, the system has performed better than conventional techniques and displayed a high level of accuracy.

The proposed approach is quite good in predicting lung cancer, according to tests done on a dataset of normal and chest CT images with right lung cancer. The CNN-based approach has been shown through analysis of the findings to properly identify malignant nodules even in their earliest stages, making it an important tool in the early identification of lung cancer.

Overall, the findings of this study indicate that using CNNs and other deep learning approaches can increase the precision and effectiveness of lung cancer diagnosis. Radiologists can more correctly and quickly identify potentially cancerous nodules by using CAD systems in conjunction with CNNs, which will improve patient outcomes.

FUTURE WORKS

The suggested CNN-based CAD system can be further optimized in the future to improve its efficiency and accuracy in identifying lung cancer. More research into the application of other deep learning methods, such as convolutional LSTM networks and recurrent neural networks (RNNs), can shed light on the usage of deep learning for the prediction of lung cancer.

In order to increase the overall accuracy of lung cancer prediction, it is also possible to investigate the use of multi-modal data, such as integrating CT scans with PET scans or genetic data. In order to guarantee the generalizability and efficacy of the CNN models across various populations, it is crucial to validate them on larger and more varied datasets.

Overall, the prospects for developing the area and enhancing the precision and efficacy of lung cancer detection and therapy seem bright for future work on lung cancer prediction utilizing CNN approaches.

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