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Lung Cancer Detection Using Transfer Learning

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ABSTRACT

Since lung cancer is still one of the most common and deadly types of cancer in the world, precise and effective screening techniques are desperately needed. Convolutional neural networks (CNNs), in particular, are deep learning algorithms that have demonstrated tremendous potential in a variety of medical image processing applications in recent years. Deep learning's area of transfer learning uses massive datasets of pre-trained networks to adapt models to domains with sparse labeled data, hence increasing the models' efficacy even further. This research uses deep learning and transfer learning approaches to give an extensive review and analysis of current developments in lung cancer detection. We talk about the difficulties of diagnosing lung cancer, such as interpreting complicated medical imaging, the disparity in class, and the scarcity of available data.In the area of lung cancer detection, we also include a summary of frequently used datasets, pre-processing methods, model topologies, and assessment measures. By means of a critical analysis of extant literature, we want to accentuate the merits and demerits of present methodologies and pinpoint prospective directions for further investigation. In the end, we want to support further efforts to provide precise, scalable, and clinically meaningful solutions for lung cancer early detection and treatment.

Keywords :- Lung Cancer, Deep Learning, Medical Image Analysis, Image Classification, Feature Extraction

I. INTRODUCTION

Lung cancer is a leading cause of cancer-related mortality worldwide, with early detection being crucial for successful treatment and improved patient outcomes. Traditional methods of lung cancer detection rely heavily on visual inspection of medical images such as X-rays and CT scans by radiologists, which can be time-consuming and prone to human error. In recent years, the advent of deep learning techniques, particularly convolutional neural networks (CNNs), has revolutionized medical image analysis by enabling automated and accurate detection of various diseases, including lung cancer.

Deep learning algorithms excel at learning intricate patterns and features from large-scale datasets, making them well-suited for analyzing complex medical images. Transfer learning, a subfield of deep learning, further enhances the performance of these models by leveraging knowledge gained from pre-trained networks on large datasets like ImageNet and adapting it to specific medical imaging tasks with limited labeled data. By fine-tuning pre-trained CNNs on lung cancer datasets, researchers can capitalize on the network's learned representations of general image features while tailoring it to detect cancer-specific abnormalities.

This paper aims to provide an in-depth exploration of the application of deep learning and transfer learning techniques in the realm of lung cancer detection. We will review the challenges associated with traditional lung cancer diagnosis methods, such as variability in image interpretation, limited availability of annotated data, and the need for timely and accurate detection. Additionally, we will discuss the potential benefits and limitations of leveraging deep learning and transfer learning for lung cancer detection, including considerations related to model interpretability, generalization to diverse patient populations, and integration into clinical workflows.

Through a comprehensive review of existing literature, we seek to elucidate the current state-of-the-art approaches, methodologies, and key findings in lung cancer detection using deep learning and transfer learning techniques. Furthermore, we aim to identify areas for future research and development, such as the exploration of multimodal imaging data fusion, incorporation of clinical metadata, and validation of model performance in real-world clinical settings.Ultimately, the integration of deep learning and transfer learning methods into lung cancer detection holds tremendous promise for advancing early diagnosis, personalized treatment planning, and ultimately, improving patient outcomes in the fight against this devastating disease.

- Lung cancer is one of the most dreadful diseases in the developing countries and its mortality rate is 19.4%.
- Early detection of lung tumor is done by using many imaging techniques such as Computed Tomography (CT), Sputum Cytology, Chest X-ray and Magnetic Resonance Imaging (MRI).
- Detection means classifying tumor two classes (i)non-cancerous tumor (benign) and (ii)cancerous tumor (malignant).
- Neural network plays a key role in the recognition of the cancer cells among the normal tissues, which in turn provides an effective tool for building an assistive AI based cancer detection.
- The cancer treatment will be effective only when the tumor cells are accurately separated from the normal cells Classification of the tumor cells and training of the neural network forms the basis for the machine learning based cancer diagnosis

The organizational framework of this study divides the research work in the different sections. The Literature survey is presented in section 2. In section 3 and 4 discussed about Existing and proposed system methodologies. Further, in section 5 shown Simulation Results is discussed and Conclusion and future work are presented by last sections 6.

II. LITERATURE SURVEY

Muthazhagan B, Ravi T, Rajinigirinath D (2021) states that with the aid of current lung cancer prediction technologies, predicting and detecting lung cancer at an early stage is a difficult challenge. An early lung tumor prediction might extend a person's life by one to five years. They created a Support Vector Machine based classification model which provided about 98% prediction accuracy in a small amount of time. However, the images were merely classified into 'abnormal' or 'normal' and did not take into account the various stages [Stage 0 – stage IV] which is what this project aims to improve on. [1].

Masud M, Sikder N, et al. (2021) uses a CNN based model for classifying the image into one of five kinds: colon adenocarcinomas, benign colonic tissues, lung adenocarcinomas, lung squamous cell carcinomas and benign lung tissues. While a peak accuracy of 96.33% has been achieved in the classification, the authors state that two out of five classes can have much improved performance with further experimentation. The dataset used is Histopathological and Histopathology is the microscopic examination of a biopsy which is an invasive process. Our approach prefers to work on CT scans which are a non-invasive mechanism to detect cancer. [2].

Sajja T,Devarapalli R,et al. Published a paper which worked on detecting lung cancer using the pre-trained CNN model called Google-Net. The deployed 60% of all neurons in the drop out layers to prevent overfitting and achieved a simplified and sparse network for classifying the CT images into benign or malignant. The model still requires testing on various dropout ratios to check for better performance accuracy. Our approach aims to construct a simplified CNN model to classify cancer along with providing medical information costs [3].

Tripathi P, Tyagi S, et al. (2019) published a paper in which they attempt to detect lung cancer using four different segmentation techniques of image processing.They conclude that marker-controlled watershed segmentation provides the most accurate results. Through the comparative analysis, it is found that CT scans tend to provide the best chance at detecting cancer and should be the preferred means to do the same. Hence, we shall use Deep Learning on CT scans to classify the various stages. [4].

Nasrullah Nasrullah et al. (2019) study focuses on developing a model that can detect cancerous nodules using CT images. They opt to employ 3D CNN after some research because of its proven performance in image analysis. To further identify the condition as benign or malignant, they use 3D MixNet to extract nodule features, which are then classified using Gradient Boosting Machine (GBM). The proposed model was validated using the free response receiver operating characteristic (FROC) evaluation matrix to obtain a FROC score of 94.21%. The suggested model outperformed all other models in terms of computational cost and desired output accuracy [5].

Siddharth Bhatia et al. (2019) present a method for detecting lung cancer using deep residual learning. They offer a series of preprocessing strategies for extracting cancer-vulnerable lung features using UNet and ResNet models. They examine the likelihood of predicting carcinogenic CT scans by comparing the effectiveness of classifiers such as Random forest and XGBoost. When the authors combine the two classifiers, they get the greatest accuracy of 84%. The constraint in this case is that the best achievable accuracy may have been higher [6].

Suren Makaju et al. (2018) made a comparison of many probable cancer detection approaches and ranked them in order of effectiveness. They decide to upgrade that model to achieve even higher accuracy by selecting the current best approach from their survey of articles.The Median and Gaussian filters were used in the pre-processing stage, and the data was then segmented using the Watershed algorithm. They went on to use support vector machines to identify diagnosed cancerous nodules as benign or malignant. This upgraded model outperformed the previous best model by 5.4%, with an accuracy rate of 92 %. The model's sole flaw is that it does not differentiate between cancer stages (I to IV) [7].

AlphaGo system, Ali I etal. (2018) developed a deep learning algorithm that takes a CT image and perceives it as a collection of states, producing a classification of whether or not a malignant nodule is present. They employ a Reinforcement Learning algorithm that improves with time and with more data.Their research shows that the model's training data has a high accuracy of 99.1%, however the validation data has a low accuracy of 64.4 %.[8].

Radhika, P.R., Nair, R.A. and Veena, G., 2019, February. A comparative study of lung cancer detection using machine learning algorithms - Lung cancer is the growth of malignant lung cells. Cancer is becoming more common, leading to more deaths for both men and women. Lung cancer is a cancer that causes lung cells to grow and divide uncontrollably. Early detection of lung cancer is crucial for improving patient outcomes, as it is a deadly disease that cannot be prevented but can be treated more effectively when caught early. Lung cancer incidence is inversely proportional to the number of chain smokers. This study investigated the use of various classification techniques, including Naive Bayes, SVM, Decision Trees, and Logistic Regression, to predict lung cancer. The primary goal of this study was to assess the effectiveness of classification algorithms in early lung cancer detection [9].

Hatuwal, B.K. and Thapa, H.C., 2020. Lung cancer detection using convolutional neural network on histopathological images. Int. J. Comput. Trends Technol, 68(10), pp.21-24 - Lung cancer is a deadly disease, but early detection and treatment can significantly improve survival rates. Medical practitioners traditionally diagnose lung cancer by examining histopathological images of biopsied tissue, but this process is time-consuming and prone to error. CNNs are a type of artificial intelligence that can be used to diagnose and classify lung cancer more accurately and quickly than traditional methods. This study evaluated the performance of a CNN model on a dataset of benign tissue, adenocarcinoma, and squamous cell carcinoma images. The model achieved an accuracy of 96.11% during training and 97.2% during validation, suggesting that CNNs have the potential to play a significant role in improving lung cancer diagnosis and treatment [10].

III.EXISTING METHOD

The total economic development of a developing country, such as India, where the majority of the population depends on health, is scared of lung cancer. Therefore, lung cancer detection ought to be more precise and reliable. The open source is used to gather lung cancer parameters. Python is the programming language in use. Numerous parameters, such as smoking, anxiety, peer pressure, chronic disease, fatigue, allergy, alcohol consuming, etc., are used to predict the lung cancer. The user starts activity in this system by using lung cancer dataset. Data gathered from the user during data collection and preprocessing processes is utilized .The initialization data is then analyzed and splitted into training and testing dataset then the model is fitted into the dataset, which evaluates the dataset and give accuracy to the user.The block diagram of existing method is shown in figure 1.

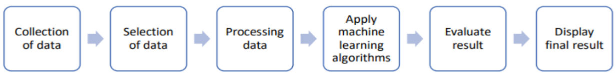

Figure 1. Block diagram of existing method

Logistic regression:

The logistic function, often known as the sigmoid function, is used in this method. This S-shaped curve can assign any real value number to a value between 0 and 1, but never exactly within those bounds. Logistic regression so models the default class probability. The logistic function, which enables us to compute the log-odds or the probit, is used to predict the likelihood.

K-Nearest neighbors:

K-Nearest Neighbours is a strategy that classifies new cases based on similarity measures and stores all of the existing examples. The test phase made use of all training data. This accelerates training while slowing down and increasing the expense of the test phase. If there are two classes, the number of neighbours in this method, k, is typically an odd number.

The naive Bayes:

The naïve Bayesian classifier is a probabilistic classifier built on the foundation of the Bayes theorem and has significant assumptions about the independence of the features. As a result, by applying the Bayes theorem, P (X|Y)=P(Y|X)P(X)P(Y), we may determine the likelihood that X will occur given that Y has already occurred

Random forest:

This forest is made up of a number of decision trees that were frequently trained using the bagging approach. The fundamental concept of bagging is to reduce variation by averaging numerous noisy but roughly impartial models.

Kernel Svm:

Using a kernel function, data can be input and then transformed into the format needed for processing. The term "kernel" is employed because the window for manipulating the data in a Support Vector Machine is provided by a set of mathematical operations.

Artificial neural networks (ANNs):

A class of machine learning techniques known as artificial neural networks (ANNs) are modelled after the form and operation of biological neural networks seen in the human brain. Artificial neurons (ANNs) are made up of interconnected nodes, also referred to as "units," that are arranged in layers. An input layer, one or more hidden layers, and an output layer are the typical divisions of the layers.

IV. PROPOSED METHOD

In Proposed Method use machine learning applied to DCNN for the development of lung cancer diagnosis. CNN is a class of deep neural network, but it is done only with the collection of data and it is not labeled. It is most commonly applied to analyse visual images.DCNN use relatively little pre-processing compared to other images classification algorithm.DCNN algorithm takes lot many images as a data to calculate.

Lung cancer is primarily caused by the irregular and unchecked cell growth of lung tissue. Smoking is one of the factors. A successful recovery is more likely when it is discovered early. New statistics each year show that there are currently over 1.6 million lung cancer patients in the United States. Both men and women are affected by the same dangerous illness. One form of filtering method that uses appealing areas is CT imaging, capture images in films. Therefore, In order to get an accurate answer right away, we can apply modern methodologies that put to use the processing of images with machine learning domains. The main objective is usually to automatically determine if lung nodules are cancerous (Malignant) or Non-Cancerous (benign). Convolutional neural network layers are used in this paper to achieve good accuracy.

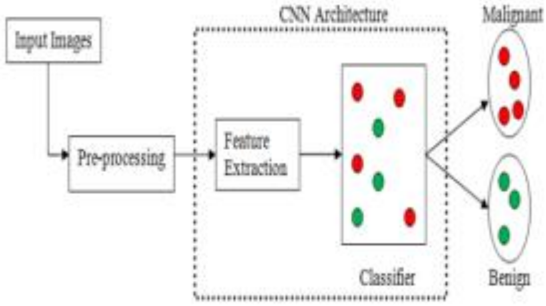

Figure 2. DCNN for Lung cancer identification

Feature extraction a kind of dimensionality reduction that efficiently represents interesting parts of a picture as a compact feature vector. This approach is beneficial when image sizes are large and a reduced feature representation is required to quickly complete tasks like image matching and retrieval. Feature detection, feature extraction, and matching are often combined to unravel common computer vision problems like object detection and recognition, content-based image retrieval is that the main aspect of any project and the face detection and recognition, and texture classification. Feature extraction a kind of dimensionality reduction that efficiently represents interesting parts of a picture as a compact feature vector. This approach is beneficial when image sizes are large and a reduced feature representation is required to quickly complete tasks like image matching and retrieval.

The below figure 3 shows block diagram of proposed method.

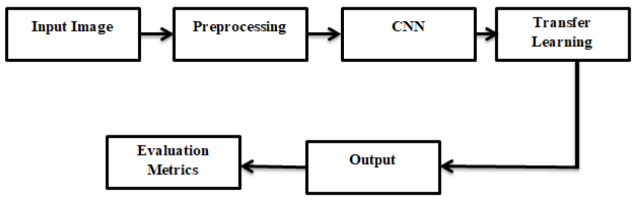

Figure 3. Block diagram of Proposed method

Lung cancer detection using deep learning and transfer learning involves several key components, including input image preprocessing, convolutional neural networks (CNNs), transfer learning, model output, and evaluation metrics. Here's an explanation of each component:

Input Image Preprocessing:

Input images, typically chest X-rays or CT scans, undergo preprocessing to enhance the quality and suitability for analysis by the deep learning model.Preprocessing steps may include resizing images to a standard resolution, normalization to ensure consistent intensity levels across images, and noise reduction techniques.Additional preprocessing steps might involve contrast enhancement, edge detection, or image augmentation techniques to increase the diversity of the dataset and improve model robustness.

CNN Architecture:

Convolutional Neural Networks (CNNs) are a class of deep learning models specifically designed for image analysis tasks.CNN architectures consist of multiple layers, including convolutional layers, pooling layers, and fully connected layers.Convolutional layers extract features from input images by applying convolution operations with learnable filters.Pooling layers downsample feature maps to reduce computational complexity and extract dominant features.Fully connected layers at the end of the network perform classification based on the extracted features.

Transfer Learning:

Transfer learning leverages pre-trained CNN models, which have been trained on large datasets such as ImageNet, for a specific task.Instead of training a CNN from scratch, transfer learning involves fine-tuning the pre-trained model on a smaller dataset relevant to lung cancer detection.During fine-tuning, earlier layers of the pre-trained model may be frozen to retain general image features, while later layers are adjusted to learn task-specific features related to lung cancer detection.Transfer learning significantly reduces training time and data requirements while improving model performance.

Model Output:

The output of the lung cancer detection model is a prediction indicating the likelihood of lung cancer presence in the input image.Typically, the model outputs a probability score, representing the confidence level of the prediction.A threshold can be applied to classify images as either positive (indicating the presence of lung cancer) or negative (indicating the absence of lung cancer).

Evaluation Metrics:

Evaluation metrics are used to assess the performance of the lung cancer detection model.Common evaluation metrics include accuracy, precision, recall, F1-score, and area under the receiver operating characteristic curve (AUC-ROC).

Accuracy measures the overall correctness of predictions, while precision and recall evaluate the model's ability to correctly identify positive cases and avoid false positives, respectively.

F1-score is the harmonic mean of precision and recall, providing a balanced measure of model performance.

AUC-ROC quantifies the model's ability to discriminate between positive and negative cases across different probability thresholds.

FLOW DIAGRAM Steps:

Data Acquisition and Preprocessing:
Obtain chest X-ray or CT scan images along with corresponding labels indicating the presence or absence of lung cancer.Preprocess the images, including resizing, normalization, and augmentation.
Transfer Learning Setup:
Select a pre-trained CNN model as a base architecture.Remove the final classification layers of the pre-trained model.
Model Construction:
Add new layers to the pre-trained model to adapt it for lung cancer detection.Include convolutional layers, pooling layers, and fully connected layers.Optionally, incorporate regularization techniques such as dropout to prevent overfitting.
Model Training:
Train the modified CNN model on the preprocessed lung cancer dataset.Use transfer learning to fine-tune the model parameters on the specific task of lung cancer detection.
Model Evaluation:
Evaluate the trained model on a separate test dataset to assess its performance.Calculate evaluation metrics such as accuracy.
Model Deployment:
Deploy the trained model in a clinical setting or research environment for lung cancer detection.
Integrate the model into existing workflows for analyzing medical images.
Monitoring and Improvement:
Continuously monitor the model's performance and update it as necessary with new data or improvements.
Conduct regular evaluations to ensure the model's accuracy and reliability.

FLOW DIAGRAM

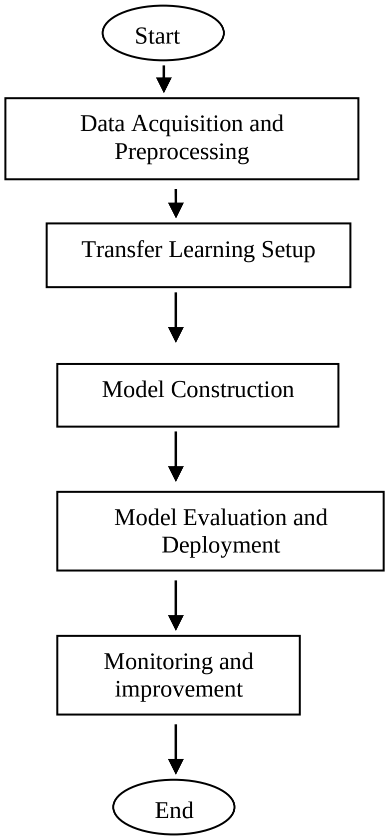

Figure 4. Flow Diagram

PERFOMANCE METRICS

The proposed method is evaluated through comprehensive simulations, considering various performance metrics:

Accuracy: It is one of the important performance measure parameter to evaluate the model. It gives correctly classified number of pixels from the given image.

Time Consumption: Time required for the process to complete its computation or its operations. If the process is simple then time taken for processing is less compared to the complex process whose computation time is more.

V. RESULTS AND DISCUSSIONS

The initial step is to obtain lung CT images of cancer patients. It comprises CT images of healthy individuals as well as lung cancer patients who are at various stages of the disease. In malignant tumors, cancer is present (ie., they invade other sites). In the lymphatic or circulatory systems, they can spread to far-off locations.

A tumor is said to as "benign" if it does not spread from its initial place to other regions of the body. They don't spread to nearby structures or to far-off regions of the body. Benign tumors frequently have clearly defined borders and develop gradually. Normal benign tumors do not pose a threat.

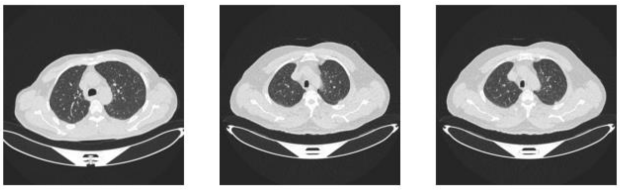

Figure 5. Benign cases

Figure 6. Malignant cases

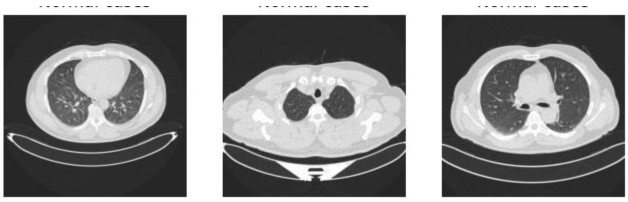

Figure 7. Normal cases

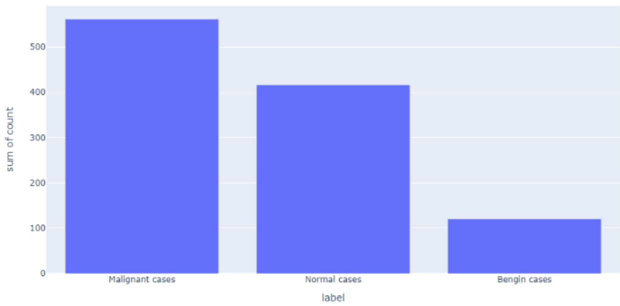

Figure 8. Data Analysis of cases

After this create custom CNN model and the obtain the accuracy,loss.

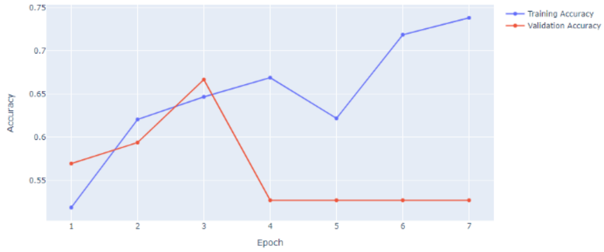

Figure 9. Training and validation Accuracy

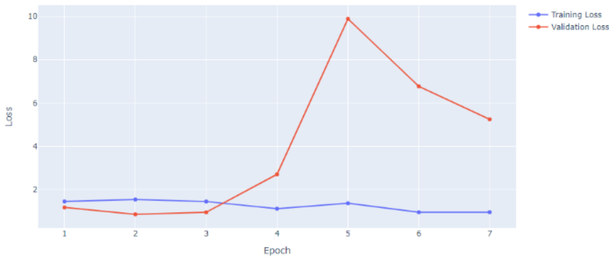

Figure 10. Training and validation loss

Then Using Pretrained Model InceptionV3,and fine tuning pretrained model Inception v3 obtaine the graph for accuracy,loss.

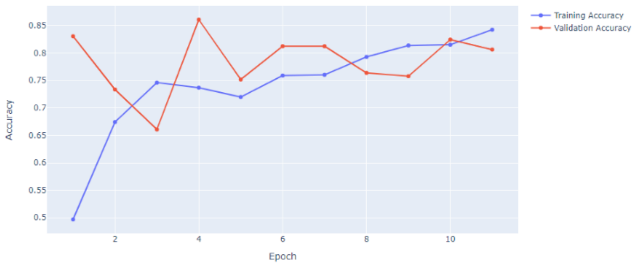

Figure 11. Training and validation Accuracy for pretrained model

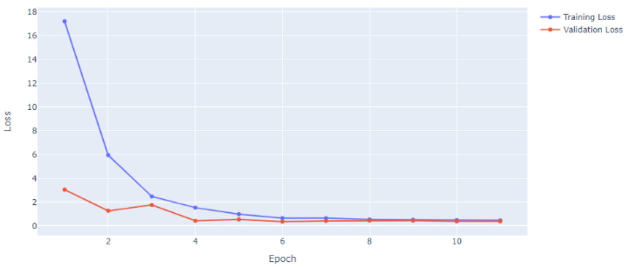

Figure 12. Training and validation loss for pretrained model

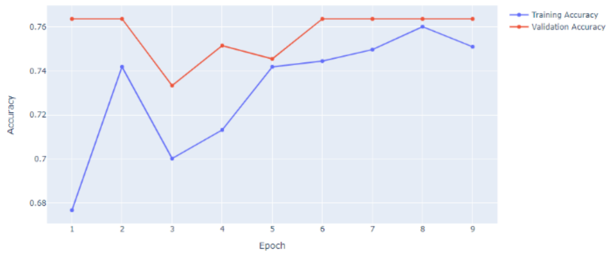

Figure 13. Training and validation Accuracy for fine tuning pretrained model

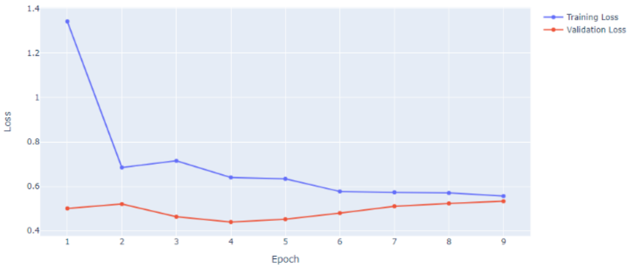

Figure 14. Training and validation loss for fine tuning pretrained model

Finally using pretrained model VGG-16 and fine tuning model VGG-16 graph is obtained for accuracy as well as loss.

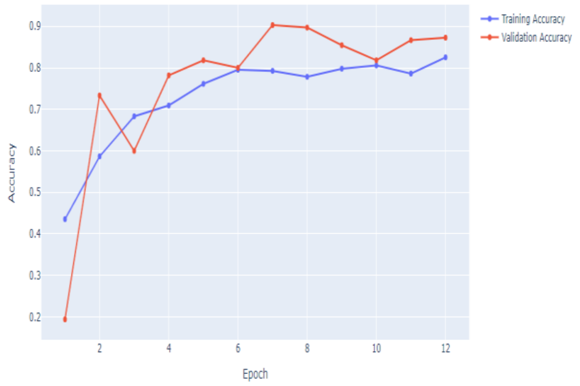

Figure 15. Training and validation Accuracy for pretrained model VGG-16

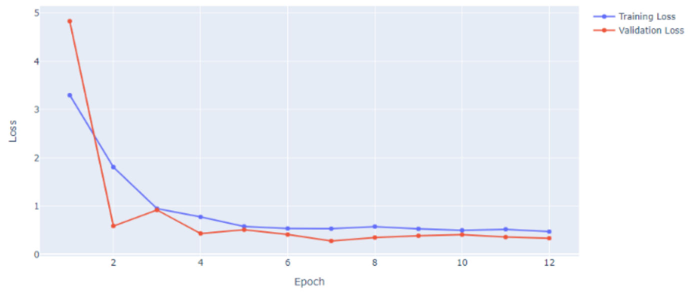

Figure 16. Training and validation loss for pretrained model VGG-16

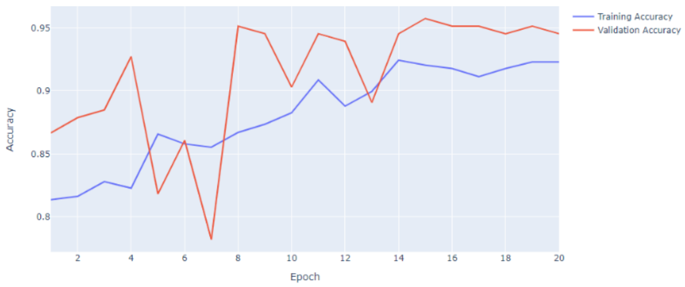

Figure 17. Training and validation Accuracy for finetuning model VGG-16

Figure 18. Training and validation loss for finetuning model VGG-16

The comparison of CNN model,VGG-16,and inceptionv3 are shown as graph below.

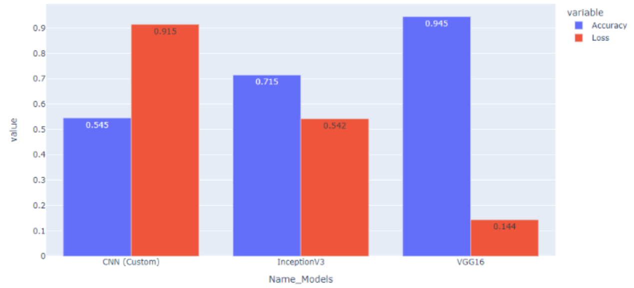

Figure 19. Accuracy and loss for different models

Model	Accuracy	Loss
CNN	0.545	0.915
Inception V3	0.715	0.542
VGG-16	0.945	0.144

Table 1. Accuracy and loss for different models

It appears that three different models were evaluated for lung cancer detection, and their corresponding accuracy and loss metrics are presented. Here's an analysis of the performance of each model:

CNN (Convolutional Neural Network):

Accuracy: 54.5%

Loss: 0.915

This CNN model achieved the lowest accuracy among the three models evaluated. The loss value indicates relatively high training error or misclassification.

Inception V3:

Accuracy: 71.5%

Loss: 0.542

The Inception V3 model performed better than the CNN with a higher accuracy of 71.5% and a lower loss of 0.542. Inception V3 is known for its effectiveness in image classification tasks due to its sophisticated architecture.

VGG-16:

Accuracy: 94.5%

Loss: 0.144

VGG-16 demonstrated the highest accuracy among the three models, achieving an accuracy of 94.5% with a relatively low loss of 0.144. VGG-16 is a well-established CNN architecture known for its depth and simplicity, which may contribute to its high performance.

Overall, VGG-16 outperformed both the CNN and Inception V3 models in terms of accuracy and loss. The results suggest that VGG-16 is the most effective model for lung cancer detection based on the provided evaluation metrics.

VI. CONCLUSION AND FUTURE SCOPE

The current proposed system is able to detect lung cancer from CT-Scan images with less processing time and acquire high level of accuracy. System is also able to classify the cancer area with minimal error rate. System uses Region Growing Segmentation, Edge Detection and CNN for acquiring such accuracy which is higher.

Lung cancer detection using deep learning and transfer learning holds tremendous promise for improving early diagnosis, treatment planning, and patient outcomes. Through the integration of advanced machine learning techniques with medical imaging, researchers and clinicians can leverage the power of convolutional neural networks (CNNs) and transfer learning to develop accurate and efficient detection systems.

In conclusion, lung cancer detection using deep learning and transfer learning represents a promising approach for enhancing early diagnosis and improving patient outcomes. With ongoing research and collaboration between researchers, clinicians, and industry partners, we can harness the full potential of artificial intelligence to combat this devastating disease.

VII. FUTURE SCOPE

The future scope of lung cancer detection using deep learning and transfer learning is vast and holds significant potential for further advancements. Here are some areas of future exploration and development:

Multimodal Data Fusion: Integrating information from multiple imaging modalities, such as combining chest X-rays with CT scans or incorporating clinical data, can enhance the accuracy and robustness of lung cancer detection models. Future research could focus on developing methods for effectively fusing multimodal data to improve diagnostic performance.

3D Imaging Analysis: While much of the current research has focused on 2D imaging analysis, the utilization of 3D imaging data, such as volumetric CT scans, offers additional insights into lung cancer detection. Future studies could explore deep learning techniques tailored to 3D image analysis, enabling more comprehensive assessment of lung nodules and lesions.

VIII. ACKNOWLEDGEMENT

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