RESEARCH REPORT

DETERMINATION / IDENTIFICATION OF COPD THROUGH CT SCAN IMAGES USING MACHINE LEARNING TECHNIQUES

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1. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a prevalent lung condition characterized by high global incidence, substantial mortality rates, and considerable medical expenses. The World Health Organization (WHO) has projected that COPD is anticipated to become the third leading cause of death worldwide by 2030. However, individuals in the early stages of COPD often go unnoticed as they may exhibit no symptoms or only mild ones. It is common for patients to be diagnosed at the moderate-to-severe stage, significantly impacting their quality of life and leading to a surge in treatment costs. Recognizing COPD early on is crucial, as it is associated with reduced risk of exacerbations, fewer concurrent health issues, and lower overall healthcare expenses. The importance of early detection of COPD is increasingly acknowledged, emphasizing the need to identify the condition in its initial stages.

COPD manifests as a highly diverse disease, exhibiting various imaging phenotypes and histopathological features such as emphysema, bronchial wall thickening, gas trapping, interstitial lung abnormalities, bronchiectasis, and more. Computed tomography (CT) has emerged as a valuable tool for capturing the presence, pattern, and extent of these phenotypic abnormalities associated with COPD, making it one of the most commonly employed imaging modalities for characterizing the heterogeneities of the disease. With the widespread use of CT scans, there is an opportunity to leverage these imaging studies to identify individuals affected by COPD at an early stage.

In our research, we have implemented novel machine-learning techniques to discern and detect COPD based on CT scan images.

2. METHODS

To streamline the processing of CT scan images, our approach involves an initial conversion of DICOM images to PNG format. Subsequently, we employ advanced image classification techniques, specifically utilizing the Vision Transformer model.

2.1 Vision Transformer

The Vision Transformer, or ViT, represents a groundbreaking neural network architecture that has gained prominence in computer vision tasks. Unlike traditional convolutional neural networks (CNNs), ViT relies on a transformer architecture, which was initially designed for natural language processing but has proven effective for visual data as well.

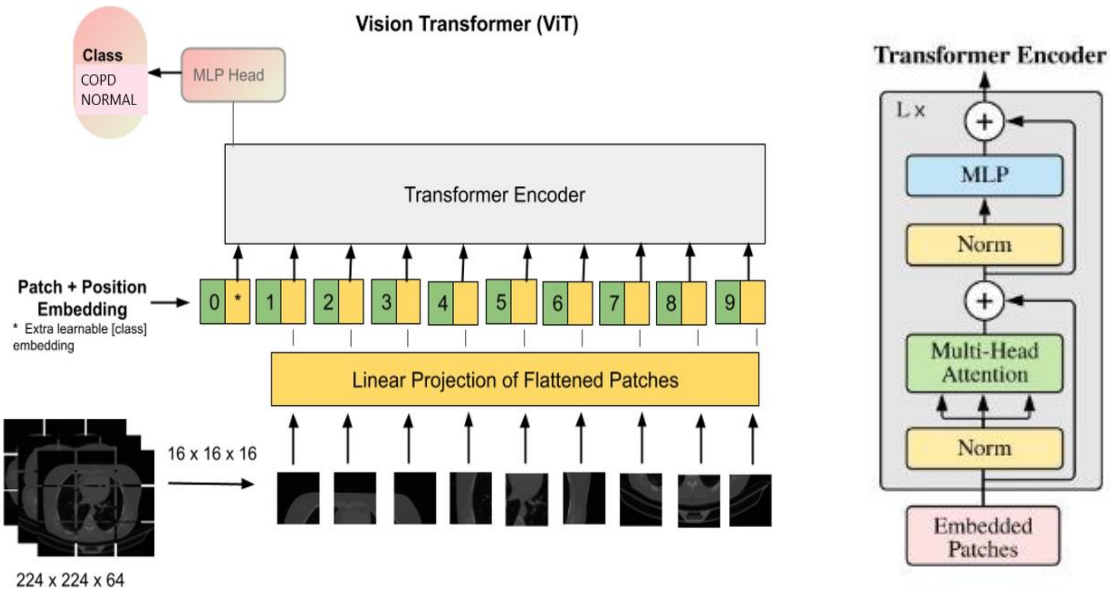

Fig. 1

Fig. 1 depicts the diagram of Vision Transformer model architecture

Model Architecture:

- We have set up a Vision Transformer (ViT) model using pre-trained weights from the ViT-Base model and modified the classifier head for our binary classification task.
- The Vision Transformer consists of a convolutional projection layer (Conv2d), an encoder (Encoder) with multiple transformer blocks, and a linear classifier head (Linear).
- The convolutional projection layer processes the input image before passing it through the transformer encoder.
- The encoder is composed of multiple transformer blocks, each containing a series of attention and feedforward layers.
- The linear classifier head (heads) is modified to have an output size matching the number of classes (in this case, 2: 'copd' and 'normal').
- The classifier head is the only trainable part of the model.

3. DATA

For our study, we used a custom dataset that contains 3708 CT scan images which were separated into 2 classes: COPD and NORMAL.

We have used the PyDICOM library to read DICOM files, extract pixel data, and apply a windowing technique for displaying CT scan images**.**

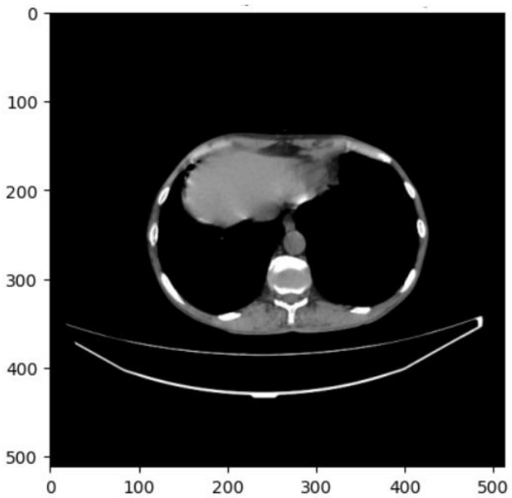

Fig. 2

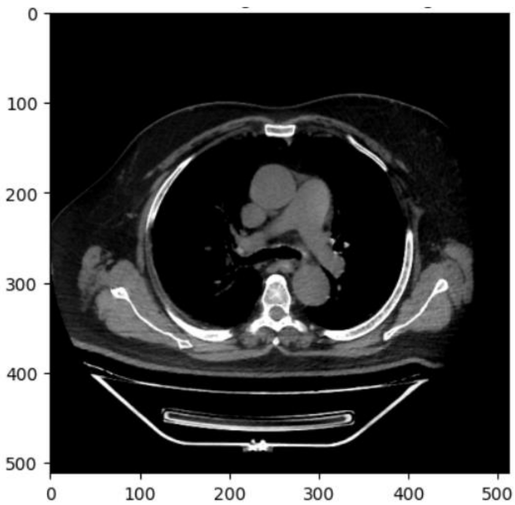

Fig. 3

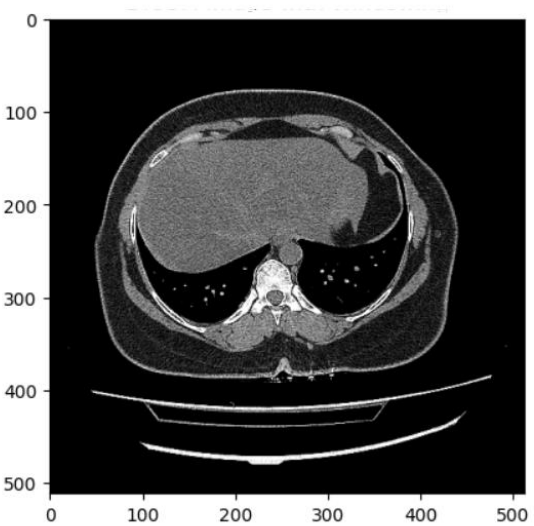

Fig. 4

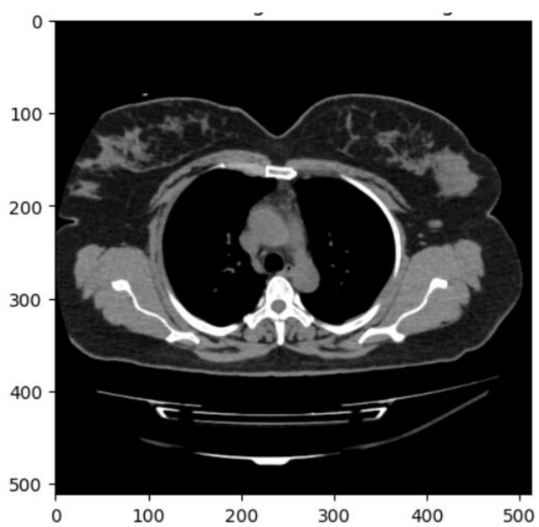

Fig. 5

Fig. 2 and Fig. 3 show CT scan images of COPD-affected patients, and Fig. 4 and Fig. 5 show CT scan images of normal patients.

4. EXPERIMENTAL RESULTS

In this study, we implemented Vision Transformer on the custom dataset for binary classification of CT scan images. The purpose of this study was to evaluate the performance of the model on this dataset.

Vision Transformer:

After evaluation of the performance of ViT, we get the following results:
The model has achieved a test accuracy of 86.29% 1. Table 1 shows the precision, recall, f1-score, and support for both classes: “COPD” and “Normal”. The “COPD” class has a precision of 0.85, a recall of 1.00, and f1-score of 0.92 with a support of 279. The “Normal” class has a precision of 1.00 but only 0.45 recall leading to an f1-score of 0.62 with a support of 93.

Based on the results, the model seems to be performing well in classifying COPD cases. However, the recall score for the “Normal” class is low, indicating that the model is not able to identify all the “Normal” cases correctly.

Table 1

	Precision	Recall	F1-score	Support
COPD	0.85	1.00	0.92	279
Normal	1.00	0.45	0.62	93
Accuracy			0.86	372
Macro avg	0.92	0.73	0.77	372
Weighted avg	0.88	0.86	0.84	372

Test Accuracy: 86.29%

5. CONCLUSION

In conclusion, our research aimed to determine and identify Chronic Obstructive Pulmonary Disease (COPD) through CT scan images using machine learning techniques, specifically employing the Vision Transformer model. The Vision Transformer demonstrated promising results with a test accuracy of 86.29%. While achieving a high precision, recall, and f1-score for the COPD class, indicating its proficiency in identifying COPD cases, there is room for improvement in recognizing normal cases.

The model's exceptional precision in the "Normal" class is counterbalanced by a lower recall, suggesting a challenge in correctly identifying all normal cases. This emphasizes the importance of refining the model to enhance its ability to accurately identify individuals without COPD. Despite this limitation, the research signifies a significant step towards early detection of COPD using CT scan images and machine learning techniques. Further optimization and validation on larger datasets are essential to enhance the model's overall performance and reliability for potential clinical applications, contributing to the early diagnosis and effective management of COPD, ultimately reducing associated healthcare costs and improving patients' quality of life.