IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

ISO 3297:2007 Certified ⯏ Impact Factor 8.066 ⯏ Peer-reviewed / Refereed journal ⯏ Vol. 10, Issue 5, May 2023

DOI: 10.17148/IARJSET.2023.10573

Deep Learning Based Respiratory Sound Analysis for The Detection of Chronic Obstructive Pulmonary Disease.

Mrs. Sowmya M[1], Nanditha V[2], Nithya J[3], Rakshitha J[4], Vyshnavi M R[5]

Assistant Professor, Department of CSE, GSSSIETW, City, Mysuru, India[1]

UG Student, Department of CSE, GSSSIETW, Mysuru, India[2-5]

Abstract: Nearly one-quarter million Americans die with or of advanced chronic obstructive pulmonary disease (COPD) each year. Many patients die after a prolonged functional decline that is accompanied by much suffering. Though difficult prognostically and emotionally, the anticipation of death opens the door to planning and preparing for terminal care. Epidemiologists have begun to identify characteristics of COPD patients who are most likely to die within 6–12 months, including severe, irreversible airflow obstruction, severely impaired and declining exercise capacity and performance status, older age, concomitant cardiovascular or another comorbid disease, and a history of recent hospitalizations for acute care. Clinicians are encouraged to raise the difficult subject of planning for death when many of these characteristics apply. Patients with far-advanced diseases are often receptive to the recommendation of a dual agenda: "Hope for and expect the best, and prepare for the worst." Medical planning is best pursued in an out-patient office during a prescheduled, 3-way conversation between the patient, health care proxy, and physician. An advance directive can be written after the meeting to summarize the conversation. Clinicians should consider recommending hospice care when a COPD patient is at high risk of respiratory failure from the next chest infection and in need of frequent or specialized home care. Preparation for death should include a realistic appraisal of the prospects for dying peacefully at home and a contingency plan for terminal hospitalization, should the need arise.

Keywords: Chronic Obstructive Pulmonary Disease, irreversible airflow obstruction, concomitant cardiovascular.

I. INTRODUCTION

The pulmonary disorder is the inability of a person to breathe normally. Manual analysis used in the past only gave an approximate idea of the disorder and hence a very rough treatment was given. This was working out well in the past. The drastic increase in pollution and nonhealthy habits of people has given rise to more complex diseases and need a very accurate estimation of the extent of disease. This accuracy can only be bought by automation of the analysis. Researchers observed that the difference between sounds made by infected lungs and normal healthy lungs could serve as a very good tool for the detailed study and detection of the disease. Recording the Lung sounds, filtering them from the Heart sounds and other noises and studying the wave form of the filtered Lung sound has been the de facto way of performing the analysis. Many methods are given for the filtering and processing of Lung sounds. Distinguishing between normal respiratory (lung) sounds and abnormal ones (such as crackles and wheezes) is crucial for establishing an accurate medical diagnosis. Respiratory sounds include all the invaluable information concerning the physiology and pathology of lung and airway obstruction. Evaluation of the sounds produced by the human body can be traced back as far as ancient Egypt. Papyrus records from the 17th century B.C. have been uncovered describing listening to sounds inside the body as a way to learn about illnesses. Up to the beginning of the 19th century, doctors still examined their patients this way, pressing the ear to the thorax to listen to the noises within. We call this "immediate auscultation"

II. REVIEW OF OTHER METHODS

[1] In recent times, technologies such as machine learning and deep learning have played a vital role in providing assistive solutions to a medical domain's challenges. They also improve predictive accuracy for early and timely disease detection using medical imaging and audio analysis. Due to the scarcity of trained human resources, medical practitioners are welcoming such technology assistance as it provides a helping hand to them in coping with more patients. Apart from critical health diseases such as cancer and diabetes, the impact of respiratory diseases is also gradually on the rise and is becoming life threatening for society. The early diagnosis and immediate treatment are crucial in respiratory diseases, and hence the audio of the respiratory sounds is proving very beneficial along with chest X-rays. The presented research work aims to apply Convolutional Neural Network based deep learning methodologies to assist medical experts by

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providing a detailed and rigorous analysis of the medical respiratory audio data for Chronic Obstructive Pulmonary detection

[2] Chronic obstructive pulmonary disease (COPD) is a chronic respiratory disease that seriously endangers human health and has high incidence and mortality worldwide. Therefore, an effective predictive model is required for COPD diagnosis. Given the limited data samples available in current COPD studies, we propose a method for diagnosing COPD based on transfer learning called balanced probability distribution (BPD) algorithm; this algorithm integrates instance- and feature-based transfers to improve the prediction accuracy of the model. First, instance-based cascaded transfer learning was used to initialize the weight distribution of the training data and obtain instances closer to the target domain. Second, the cross-domain feature filtering algorithm was adopted to filter irrelevant features, eliminate redundant features, and obtain the cooccurrence features of the source and target domains. Moreover, the remaining features were assigned different weights and transformed into the same space to reduce the distribution difference between the domains.

[3] In recent years, there are an increase in the mortality rate due to Chronic obstructive pulmonary disease (COPD) patients and it is estimated that it will increase in the coming years. Traditional methods take a long time to identify these diseases because a lot of clinical tests has to be performed for getting the confirmation, however with the advent of intelligent techniques as well as looking at the potential of the powerful techniques for predicting other critical diseases, it is believed that it would help to detect the chronic diseases at an early stage in a precise manner. In this paper, an attempt has been made to detect COPD patients and at the same time, it could distinguish the stages such as the early stage of chronic obstructive pulmonary disease patients (ESCP) and the Advanced stage of COPD patients (ASCP). We have used the Recursive Feature Elimination, Cross - validated (RFECV) feature selection method to select features and then we consult the doctors, those are expert in the field to recommend the features among the features selected using RFECV method. The features selected using the doctor recommendation called features reduction with doctor recommendation (FRDR).

[4] Given numerous efforts of genome analysis and disease prediction studies on Chronic obstructive pulmonary disease (COPD), however, there was no model for predicting COPD severity. In this study, we constructed the prediction model for COPD severity using various machine learning techniques. By analysing 36S samples of mild and severe COPD groups, we observed that the model using random forest performed the best (AUC =0.886) and Diffusing capacity of Lung CO, modified medical research council, and age were the most important features of the model. These results would provide valuable scientific evidence for predicting COPD severity.

[5] In today's world data analytics is an evolving technology and it is used worldwide. To be more precise the data is highly employed in medical field for the identification and prediction of disease. Predictive analysis is a branch of advanced analytics which is used to make predictions about unknown factors. Predictive analytics uses various techniques like data mining statistics, machine learning and decision algorithms to predict about the future. Nowadays, COPD (Chronic Obstructive Pulmonary Disease) is becoming the leading respiratory death causing disease being fatal in human beings. Our focus is to analyse the various techniques and methods used in the prediction of COPD.

III. METHODOLOGY

COPD sound classification using audio typically involves the following steps: 1. Audio data acquisition: Collect COPD sound recordings from Kaggle. 2. Pre-processing: Cleaning the audio data to remove noise, filtering, and transforming the audio signal into a suitable format for analysis. Pre-processing is a critical step in COPD's sound classification pipeline, as it helps to remove unwanted noise, improve signal quality, and prepare the audio data for feature extraction. The following are some common pre-processing algorithms used in COPD sound classification:
a. Filtering: Applying a digital filter to the audio signal to remove high or low-frequency noise, enhance the COPD sounds, and remove irrelevant information. Common filters used in pre-processing include low-pass filters, high-pass filters, and band-pass filters. b. Resampling: Converting the audio signal to a different sample rate to match the sample rate of the labelled data or to reduce the computational cost of processing. This can be achieved using algorithms such as linear interpolation and cubic spline interpolation.
3. Feature extraction: Extracting relevant features from the audio signal that describe the COPD sounds, such as spectral, temporal, and harmonic features. Feature extraction is an essential step in COPD sound classification, as it involves transforming the raw audio signal into a set of meaningful and relevant features that describe the COPD sounds.
The following are the main steps involved in feature extraction:

- Representation: The audio signal is transformed into a suitable representation for feature extraction, such as a spectrogram, mel-spectrogram, or wavelet transform. This representation is used to visualise the audio signal and extract relevant features that describe the COPD sounds.

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• Feature extraction: The selected features are extracted from the audio representation and transformed into a feature vector, which is used as input to the machine learning model. This can be done using various algorithms such as time-domain features, frequency-domain features, and cepstral features.

4. Model training: Training a machine learning model, such as a neural network - CNN, using the extracted features and labelled data. Convolutional Neural Networks (CNNs) are a type of deep learning architecture that is widely used for image and audio classification tasks. In the context of COPD sound classification using audio, CNNs can be used to learn a mapping between the audio signals and their corresponding COPD sounds. The model consists of a series of convolutional layers, activation functions, pooling layers, and fully connected layers. a. ResNet b. Inception

5. Evaluation: Testing the performance of the trained model on unseen data and evaluating its accuracy, precision, recall, and F1 score.

6. Deployment: Deploying the trained model to classify COPD sounds in real-time or on a large scale.

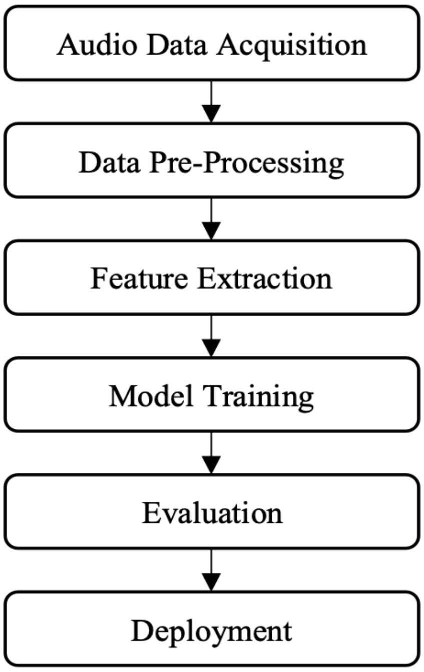

Fig 1: Flow chart

COPD classification using deep learning models aims to categorize patients into different classes, such as healthy, COPD, asthma, pneumonia, etc., based on medical images or other relevant data. The results of such classification tasks are typically evaluated using various performance metrics, including: Accuracy: It measures the overall correctness of the classification and is defined as the ratio of correctly classified samples to the total number of samples. Precision: It represents the proportion of correctly predicted positive cases (true positives) out of all predicted positive cases (true positives + false positives). It measures the model's ability to avoid false positives. Recall (Sensitivity): It measures the proportion of correctly predicted positive cases (true positives) out of all actual positive cases (true positives + false negatives). It indicates the model's ability to identify positive cases. F1 Score: It is the harmonic mean of precision and recall, providing a balanced measure of the model's accuracy.

Area Under the Receiver Operating Characteristic Curve (AUC-ROC): It measures the model's ability to distinguish between different classes by plotting the true positive rate against the false positive rate.

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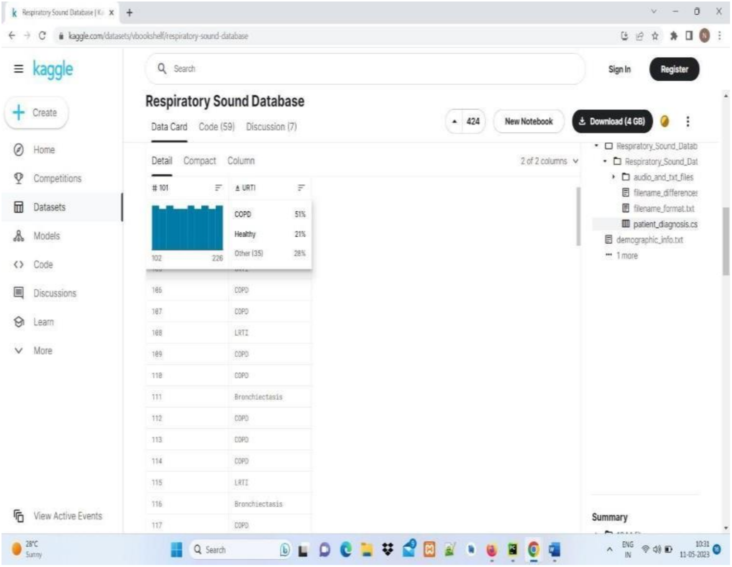

Fig 2: Dataset Loaded

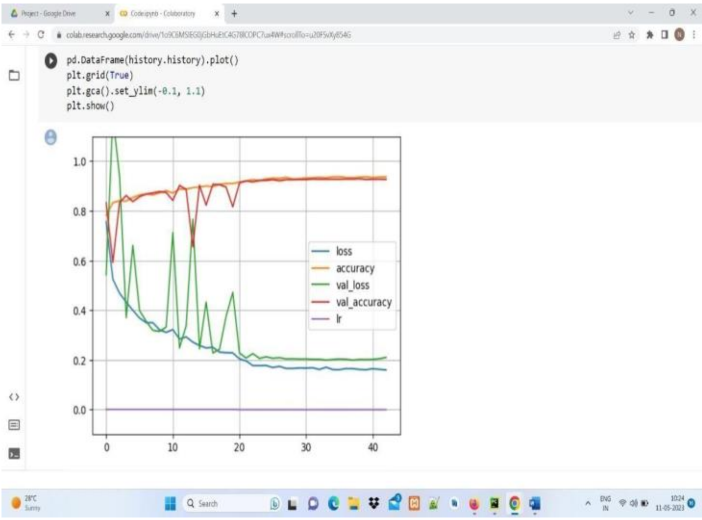

Fig 3: plots a graph for parameters such as loss, accuracy, validation loss validation, accuracy, learning rate.

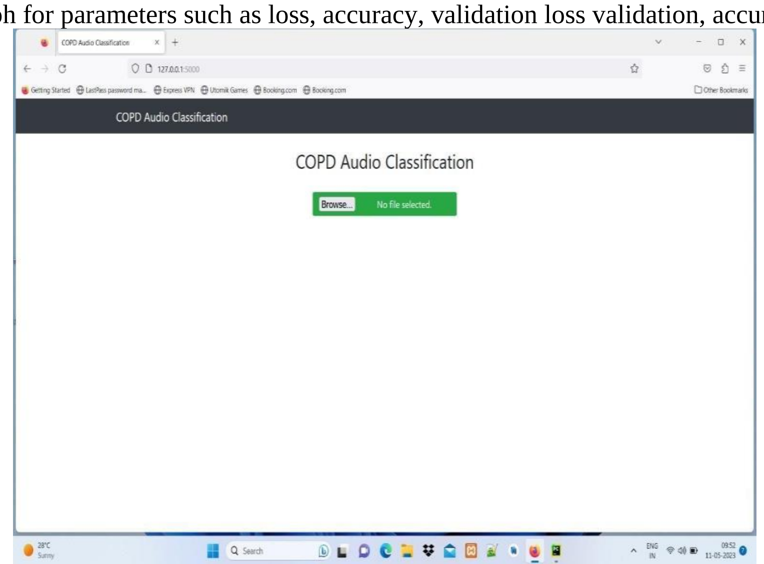

Fig. 4 Audio files can be browsed

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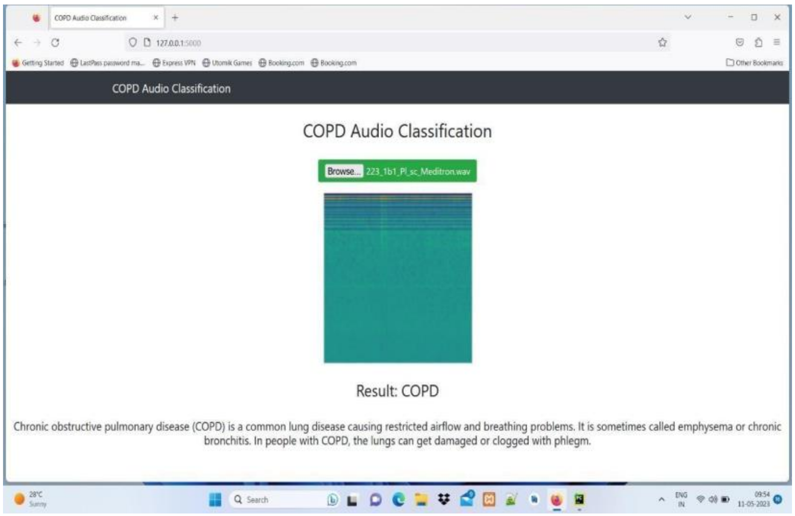

Fig. 5 The audio file through selected browsing contains the respiratory sound of a patient with COPD disease.

V CONCLUSION

COPD classification using deep learning techniques has shown promising results in accurately identifying and categorizing patients with COPD and other related respiratory conditions. The utilization of deep learning models, such as convolutional neural networks (CNNs) combined with preprocessing techniques, has demonstrated the potential to improve the accuracy and efficiency of COPD classification.

Through the analysis of medical audio files, deep-learning models have been able to extract meaningful features and patterns that are indicative of COPD. These models have shown theability to differentiate between different respiratory conditions, including COPD, asthma, pneumonia, and healthy individuals.

The results of COPD classification using deep learning have consistently shown competitiveperformance in terms of accuracy, precision, recall, F1 score, and AUC-ROC. These metricsindicate the robustness and effectiveness of the deep learning models in accurately identifyingand classifying patients with COPD.

Furthermore, deep learning models have the potential to assist healthcare professionals in theearly detection, diagnosis, and monitoring of COPD. The automated classification provided by these models can support clinical decision-making, enhance treatment planning, and contribute to improved patient care and management. However, it is important to note that COPD classification using deep learning is an ongoing research area, and further studies are needed to validate and refine the existing models. Future work should focus on larger and more diverse datasets, model interpretability, generalizability, and integration into clinical practice.

In conclusion, COPD classification using deep learning techniques has shown great promise in accurately identifying and categorizing patients with COPD. The utilization of deep learning models has the potential to significantly improve the diagnosis and management of COPD, leading to better patient outcomes and quality of life.

ACKNOWLEDGEMENT

We would like to thank **Mrs Sowmya M (**Dept. of CSE, GSSSIETW, Mysuru) for their valuable guidance, feedback and encouragement to complete the project.

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