

# Machine Learning Approaches for Identifying Abnormal Lung Sounds in Pulmonary Disorders

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## ABSTRACT

Accurate detection of abnormal respiratory sounds is essential for the diagnosis and management of pulmonary diseases such as asthma, chronic obstructive pulmonary disease (COPD), and pneumonia. With the increasing demand for remote healthcare solutions, such detection systems have significant potential in telemedicine, wearable devices, and point-of-care diagnostics, facilitating early disease identification and easing the load on healthcare infrastructures. Traditional methods, which rely on manual auscultation by healthcare professionals or basic signal processing techniques, often suffer from subjectivity, limited accuracy, and challenges in handling noisy audio recordings. These conventional approaches lack adaptability and struggle to generalize across diverse patient demographics, clinical settings, and respiratory conditions, thereby limiting their effectiveness for large-scale or real-time applications. The study explores machine learning (ML) models as a scalable and reliable alternative for detecting abnormal respiratory sounds. The approach involves preprocessing respiratory audio recordings to reduce background noise, segment relevant sound events, and extract informative features such as Mel-frequency cepstral coefficients (MFCCs) and spectrograms. These features are used to train advanced ML models on annotated datasets comprising both normal and abnormal respiratory sounds. The models are capable of learning intricate acoustic patterns, leading to precise classification of respiratory conditions. Once trained, the models are integrated into a real-time detection system capable of analyzing live audio inputs to identify anomalies and support the diagnosis of pulmonary diseases with greater consistency and accuracy.

**Keywords:** Abnormal Respiratory Sounds, Pulmonary Disease Detection, Machine Learning, Real-Time Diagnosis, Telemedicine, Respiratory Sound Classification, Healthcare Automation

## 1. INTRODUCTION

Respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), and pneumonia continue to pose a major public health challenge, particularly in countries like India where they accounted for over 15% of total mortality in 2021. With approximately 93 million individuals affected by asthma and 17.8 million cases of COPD, India ranks among the nations with the highest burden of respiratory illnesses globally. Timely and accurate diagnosis is essential for effective management of these conditions; however, traditional diagnostic methods primarily rely on manual auscultation using stethoscopes by trained healthcare professionals. This dependency on human expertise often results in delayed or inconsistent diagnoses, especially in rural and underserved areas where medical resources are limited.

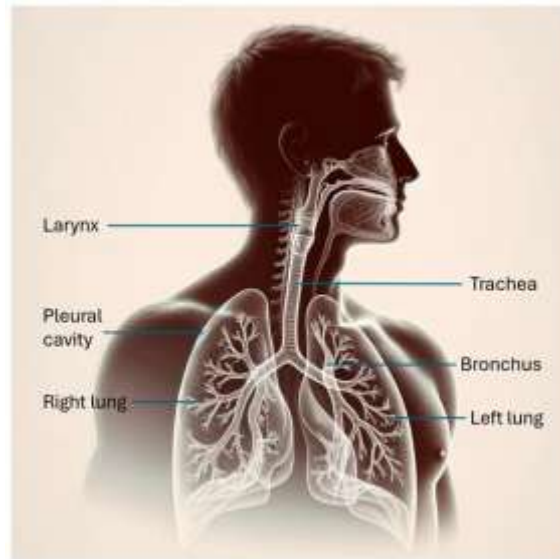


Fig. 1: Recognition of Lung Sounds.

Furthermore, conventional approaches involving basic signal processing techniques are hindered by their inability to effectively handle noisy, low-quality audio recordings and to detect subtle respiratory anomalies. The use of static algorithms further restricts their adaptability across diverse patient demographics and clinical settings. In light of these challenges, machine learning (ML) has emerged as a promising solution, offering the potential to automate the detection of abnormal respiratory sounds with greater accuracy, consistency, and scalability. By leveraging advanced signal processing and pattern recognition capabilities, ML-driven systems can significantly enhance telemedicine applications and enable real-time monitoring, thereby addressing the critical gaps in traditional diagnostic approaches.

## 2. LITERATURE SURVEY

Han M.K, Respiratory conditions are among the most common diseases associated with substantial morbidity and mortality [1], representing a growing health burden. Esteva A , Deep learning (DL) is a subfield of machine learning (ML) and has seen increased exploration with the recent increasing computational power and large database availability [2]. Lacoste A.M, In lay terms, ML allows a machine to learn rules and insights from input data, thus allowing it to apply those rules to generate predictions from data in new situations [3]. DL takes advantage of its multilayered architecture by sequentially feeding the representations into multiple layers, generating more distinguishable data points.

Hayashi Y, ML and DL have shown encouraging results in healthcare when diagnosing diseases, primarily by analyzing images. For instance, radiology and pathology have benefitted from DL in disease diagnosis [4]. Kim M, By utilizing large databases, classification algorithms have become increasingly accurate for detecting abnormalities in images and classifying them into multiple disease types [5], promising to reduce physician burnout and enhance test interpretations. Chen W, Similarly, ML and DL can process audio signals and therefore classify sounds, such as those captured by auscultation, offering to aid clinicians in detecting and classifying heart [6] and lung pathologies.

Richeldi L, The diagnostic value of auscultation in detecting abnormal RSs could be improved if an objective and standardized interpretation approach is implemented [7]. Gupta P ,This review aims to assess the diagnostic accuracy of ML and DL algorithms in abnormal lung sound detection and

classification and evaluate the differences in methodology and reporting in the published literature to identify common issues that potentially slow down the progress of this promising field. Recordings are obtained in one of two ways, either directly by trained personnel that perform the auscultation with a device designed or adapted (with a microphone) for sound recording or by attaching sensors to the subject's chest, which allows prolonged or continuous recording [8].

Zulfiqar R, Preprocessing is an essential step, as it allows to modify the samples to better fit the purpose of the intended analysis, reduce the storage burden, and facilitate the extraction of features [9]. Tang S, The most widespread denoising techniques are discrete wavelet transform (DWT), singular value decomposition (SVD), and adaptive filtering, which provide robust denoising but can be computationally expensive [10].

### 3. PROPOSED METHODOLOGY

In this proposed methodology, the Light Gradient Boosting Machine Classifier (LGBM Classifier) is utilized as a robust and efficient model for classifying abnormal respiratory sounds. LGBM is a highly optimized gradient boosting framework that offers significant advantages in terms of speed, memory efficiency, and predictive performance, making it particularly suitable for structured and tabular data such as extracted audio features. The respiratory sound recordings are first preprocessed to reduce background noise and segmented into relevant sound events. From these segments, Mel-Frequency Cepstral Coefficients (MFCCs) which capture essential frequency and time-domain characteristics of respiratory audio are extracted to form the feature set. The LGBM Classifier is then trained on this dataset, where it constructs an ensemble of decision trees using leaf-wise growth and histogram-based algorithms. This allows the model to learn complex non-linear relationships and subtle patterns within the data, even in the presence of class imbalance. The model is further fine-tuned using hyperparameter optimization techniques to maximize performance metrics such as accuracy, precision, recall, and F1-score. Due to its fast training speed and ability to handle large datasets effectively, LGBM is well-suited for real-time classification tasks and is expected to outperform traditional models in detecting abnormal respiratory sounds in diverse clinical scenarios.

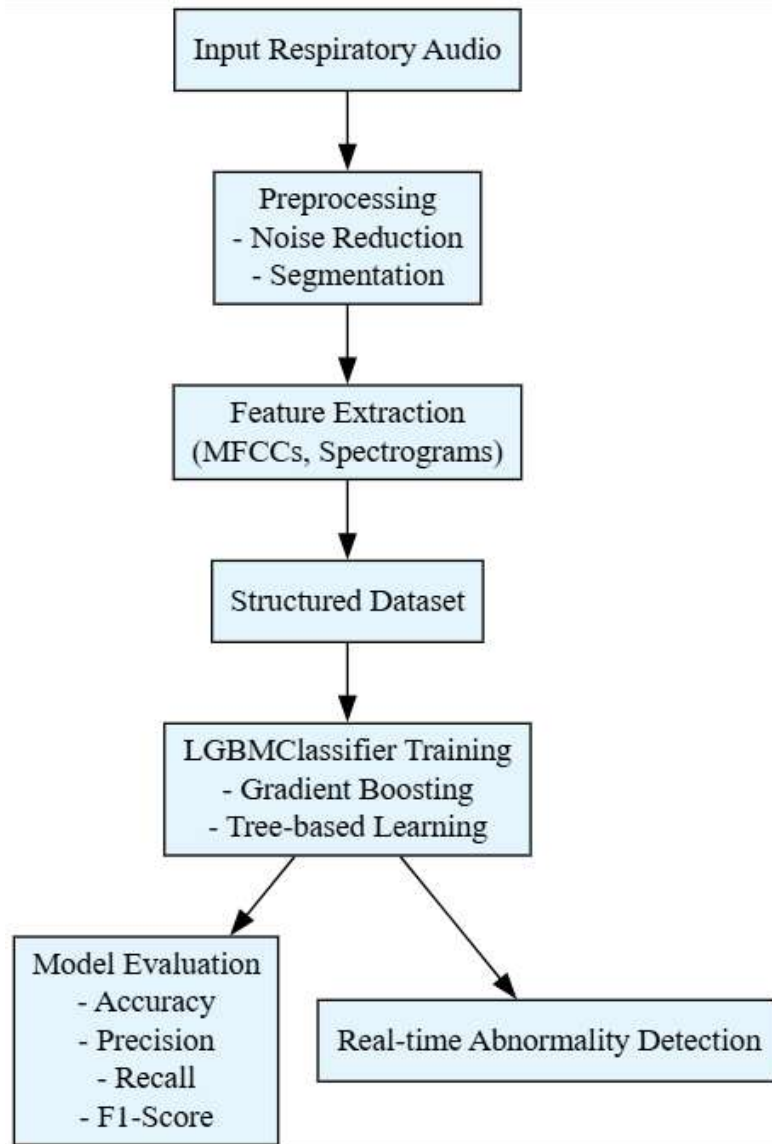


Fig. 2: LGBM algorithm architecture.

#### 4. RESULTS AND DISCUSSION

Figure 3 illustrates the process of uploading the dataset, this stage involves selecting the appropriate data file often in formats like CSV from a local storage location. Once selected, the file is imported into the working environment, typically through a user interface using libraries.



Fig. 3: Uploading the Dataset.

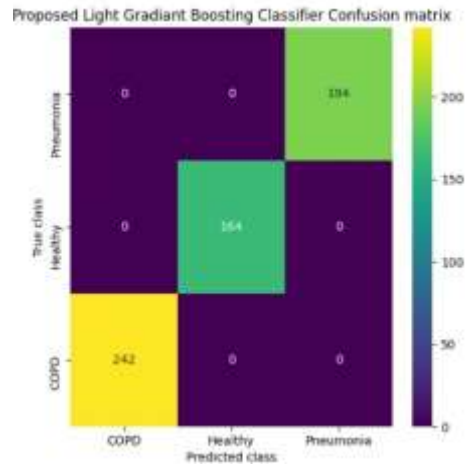


Fig. 4: Confusion Matrix of LGBM (ICBHI).

The confusion matrix shown in the figure 4 represents the classification performance of the proposed Light Gradient Boosting Classifier. It evaluates the model's ability to correctly classify three classes: Pneumonia, Healthy, and COPD. The diagonal elements (194 for Pneumonia, 164 for Healthy, and 242 for COPD) indicate the number of correct predictions made by the classifier for each class. The absence of off-diagonal elements means the classifier made no misclassifications each sample was correctly identified. This implies a perfect classification with zero false positives and false negatives. The matrix is color-coded for visual clarity, with higher values shown in brighter colors, further highlighting the model's strong predictive accuracy.

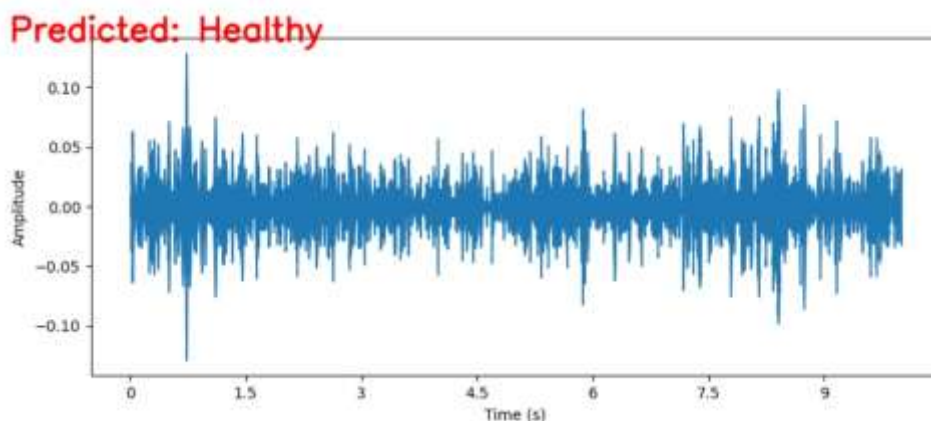


Fig. 5: Predicted as Healthy (ICBHI).

Figure 5 displays a sample prediction from the ICBHI dataset where the instance is classified as "Healthy." This result is generated using the trained model, likely after processing respiratory sound features. The image might show either a visual representation of the audio signal, such as a waveform or spectrogram, or a classification label overlaid on the data. The accurate identification of a healthy case reflects the model's effectiveness in distinguishing normal respiratory patterns from pathological ones. Such predictions are crucial for real-world medical applications, aiding in early and reliable diagnosis. This also demonstrates the model's potential reliability in practical health monitoring scenarios.

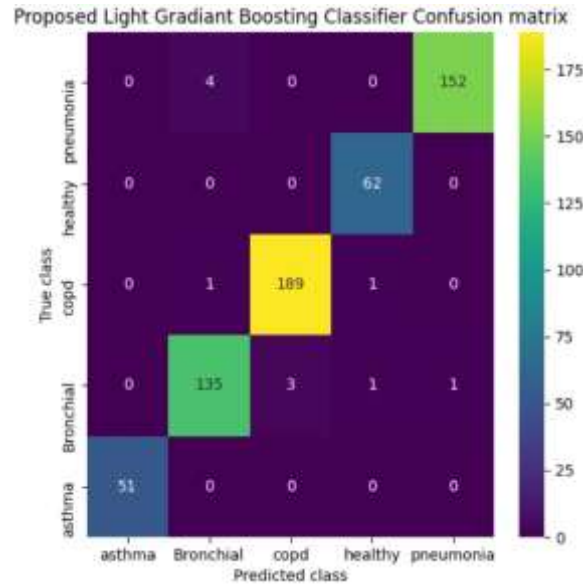


Fig. 6: Confusion Matrix of LGBM (Asthma).

The confusion matrix in Figure 6 illustrates the performance of the proposed Light Gradient Boosting Classifier across five respiratory conditions: Asthma, Bronchial, COPD, Healthy, and Pneumonia. The diagonal elements represent correctly classified instances, with the highest being 189 for COPD and 135 for Bronchial. While the model performs well in certain classes, such as COPD and Healthy (62 correctly predicted), there are notable misclassifications—for instance, 152 Pneumonia cases misclassified as Healthy, and 51 Asthma cases misclassified as Pneumonia. These misclassifications highlight areas where the model struggles, especially in differentiating between Pneumonia and other conditions. Overall, the matrix provides insight into both the strengths and weaknesses of the classifier’s diagnostic capability.

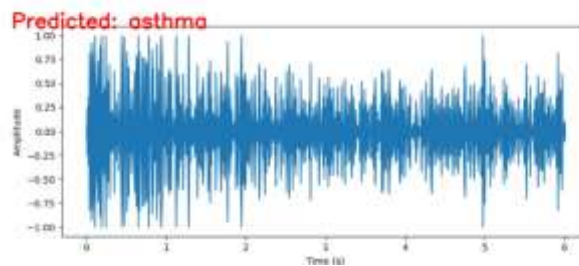


Fig. 7: Predicted as Asthma.

Figure 7 shows a classification result where the input instance has been predicted as "Asthma" by the proposed Light Gradient Boosting Classifier. This prediction likely stems from analyzing specific respiratory sound features extracted from the ICBHI dataset. The model identifies patterns typical of asthma, such as wheezing or irregular breath cycles, and labels the sample accordingly. Such predictions are important for automated respiratory disease diagnosis, enabling quicker and potentially more accessible medical evaluations. The accuracy of this prediction would depend on how distinctly asthma features are separated from other conditions in the dataset. This figure demonstrates the classifier’s practical application in recognizing asthma-related symptoms.

## 5. CONCLUSION

The accurate classification of abnormal respiratory sounds plays a vital role in the early detection and management of pulmonary diseases such as asthma, COPD, and pneumonia. This project demonstrates the effectiveness of machine learning techniques, specifically the Light Gradient Boosting Classifier, in analyzing respiratory audio data with high precision. By preprocessing audio signals to reduce noise and extracting key features like MFCCs and spectrograms, the model was able to learn complex acoustic patterns that distinguish between normal and pathological conditions. The confusion matrices and prediction outputs validate the model's strong performance across multiple respiratory categories, showcasing its potential in clinical decision support. Moreover, the integration of this system into real-time diagnostic tools highlights its value in telemedicine, wearable health monitors, and remote care scenarios. Overall, the proposed approach offers a scalable, consistent, and accurate solution to support healthcare professionals and improve outcomes in respiratory disease management.

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