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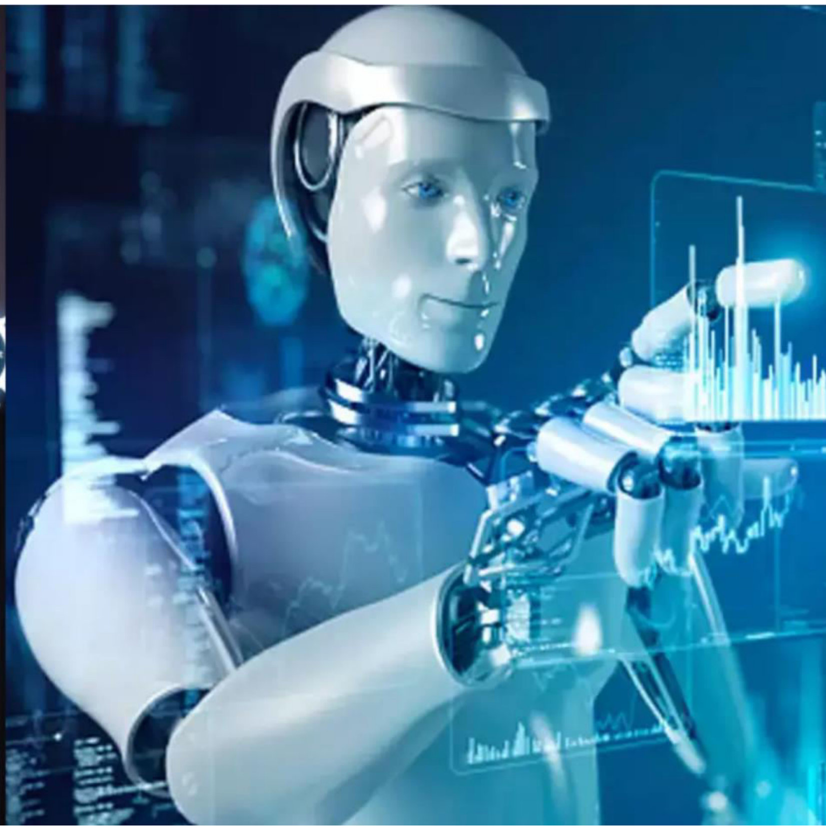

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Respiratory Disease Classification using Lung Sounds

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ABSTRACT: Respiratory diseases, including Pneumonia, Chronic Obstructive Pulmonary Disease (COPD), Bronchiolitis, and Upper Respiratory Tract Infection (URTI), pose significant health risks and require timely and accurate diagnosis for effective treatment. Traditional diagnostic methods rely heavily on clinical expertise and auscultation, which may lead to inconsistencies and misdiagnoses. With advancements in artificial intelligence, deep learning has emerged as a promising solution for medical diagnosis; however, existing models often struggle with real-world clinical accuracy.This project presents a deep learning-based classification system using Convolutional Neural Networks (CNN) and Gated Recurrent Units (GRU) for respiratory disease detection. The model processes lung sound recordings and extracts key acoustic features using Mel Frequency Cepstral Coefficients (MFCCs). To enhance model performance and adaptability, various audio transformation techniques such as pitch variation and controlled noise addition are implemented. The proposed system offers an interpretable diagnostic output, improving the accuracy and reliability of disease identification. By integrating deep learning techniques, this project aims to assist healthcare professionals with an efficient, automated, and precise method for detecting respiratory illnesses, ultimately contributing to better patient results.

KEYWORDS: COPD, URTI, GRU, MFCCs

I. INTRODUCTION

Respiratory diseases such as Pneumonia, Chronic Obstructive Pulmonary Disease (COPD), Bronchiolitis, and Upper Respiratory Tract Infection (URTI) affect millions worldwide and often lead to serious health complications.Early and accurate diagnosis is crucial for effective treatment and better patient outcomes.Unlike traditional methods like stethoscope-based auscultation, which rely on a clinician's personal experience and may vary in accuracy, modern approaches aim to reduce inconsistencies in interpretation.Advances in deep learning have enabled the development of intelligent models capable of detecting and interpreting lung sound abnormalities linked to specific respiratory illnesses.

This project implements Convolutional Neural Networks (CNN) combined with Gated Recurrent Units (GRU) to process and interpret lung sound data for disease classification.Key audio features are extracted using Mel Frequency Cepstral Coefficients (MFCCs), and classification accuracy is further improved through audio augmentation techniques such as noise addition, pitch shifting, and time stretching.Using a combination of deep learning and advanced audio feature extraction, the system offers a dependable and standardized method for diagnosing respiratory conditions.

The system is implemented as a Flask-based web application with separate access roles for admins, doctors, and labs.Labs are responsible for submitting patient lung sound recordings, which doctors then evaluate using the system's diagnostic analysis.Patients can access their diagnostic reports through the platform, making it a transparent and credible decision-support system that enhances collaboration between healthcare providers and improves patient care.

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II. LITERATURE SURVEY

Recent studies have explored the classification of respiratory sounds using deep learning and machine learning techniques. The study "Abnormal Respiratory Sounds Classification Using Deep CNN" [1] evaluated models like AlexNet, ResNet, InceptionNet, and VGG variants, with AlexNet achieving the highest accuracy of 96%, highlighting the impact of artificial noise augmentation. Kim et al. [2] utilized the VGG16 model for classifying crackles, wheezes, and rhonchi, achieving 86.5% accuracy. Gairola et al. [3] introduced RespireNet, a deep learning model for limited data settings, achieving 77.0% (2-class) and 68.5% (4-class) accuracy. Rizal and Istiqomah [4] explored time-domain features using Decision Trees and KNN, where Decision Trees achieved 89.9% accuracy. Petmezas et al. [5] developed a hybrid CNN-LSTM model with focal loss, achieving 73.69% accuracy, emphasizing the sequential nature of respiratory audio. Amose et al. [6] employed SVM and Decision Tree classifiers for wheeze and crackle classification, with SVM achieving 80% accuracy. Wanasinghe et al. [7] proposed a lightweight CNN integrating multi-feature extraction and explainable AI, reaching 87.04% accuracy. Wu et al. [8] introduced an improved Bi-ResNet model, achieving 77.81% accuracy for lung sound classification. Bae et al. [9] applied Patch-Mix Contrastive Learning with Audio Spectrogram Transformer, reporting 62.37% accuracy and highlighting transformer models' potential. Lastly, Suma et al. [10] explored multi-task learning for lung sound and disease classification, with MobileNet achieving the highest accuracy of 82.5%. Overall, these studies underline the promising role of deep learning and machine learning in enhancing respiratory disease diagnosis and sound classification.

III. METHODOLOGY

The Kaggle Respiratory Sound Database, containing 920 lung sound recordings from 126 individuals, forms the primary dataset for this project. These recordings,include 6,898 respiratory cycles, cover diseases such as COPD, pneumonia, URTI, and bronchiolitis. To guarantee the quality and reliability of the input data, preprocessing steps were carried out, including the removal of noisy samples, extraction of Mel-frequency Cepstral Coefficients (MFCCs) for feature representation, and the application of augmentation techniques like noise addition, time shifting, stretching, and pitch adjustment. Disease labels were then transformed into one-hot encoded vectors to make the classification process more structured and unbiased.

To classify the respiratory conditions, a deep learning model combining Convolutional Neural Networks (CNN) and Gated Recurrent Units (GRU) was constructed. The CNN segment, using one-dimensional convolutional layers, captures key frequency-related patterns from the MFCC features. Pooling operations help reduce the size of extracted features, while normalization ensures more stable and faster model training. GRU layers are then employed to interpret the time-dependent aspects of the lung sound signals, where update and reset gates manage the flow of important sequential information, allowing the model to focus effectively on breathing patterns that are vital for disease identification. The GRU's bidirectional capability further strengthens its ability to understand both past and future context within lung sound sequences.

Once feature extraction and sequence modeling are completed, the resulting information is passed through densely connected layers activated by ReLU functions, enabling deeper pattern learning. A softmax output layer gives the final classification, predicting the most likely respiratory disease based on the processed sound data. The model is trained by minimizing categorical cross-entropy loss and uses the Adam optimizer to refine its learning process. After training, the system's performance is evaluated on unseen samples to ensure that it generalizes well, providing reliable predictions that could assist in early respiratory disease diagnosis.

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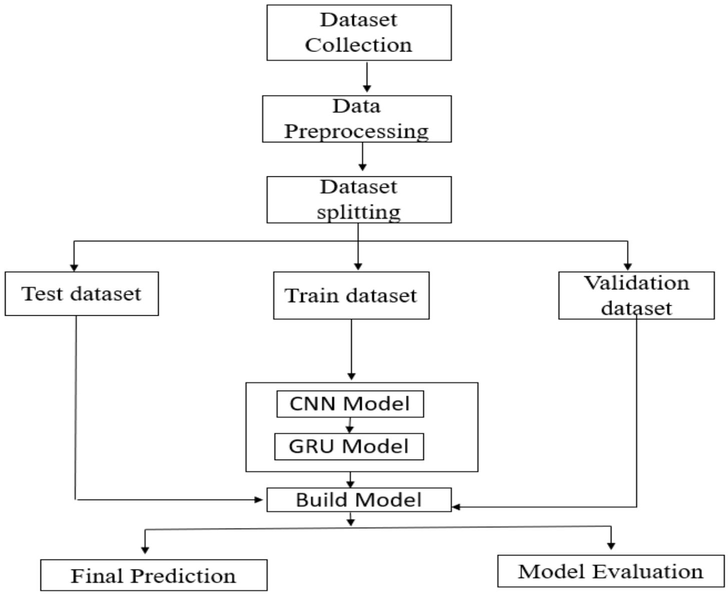
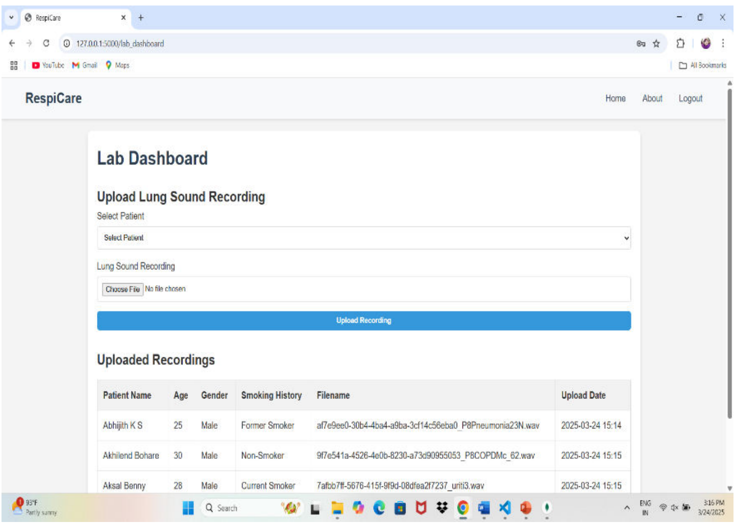


(a)

Fig. 1. Shows the system architecture of respiratory disease classification using lung sounds CNN-GRU

IV. EXPERIMENTAL RESULTS

The deep learning model achieved an impressive overall accuracy of 90% in classifying respiratory diseases from lung sound recordings. To assess its performance, the model was evaluated using several important metrics, including precision, recall, and F1-score. These metrics provided a detailed evaluation of its classification efficiency across various conditions.In terms of precision and recall, the model performed exceptionally well with Bronchiolitis, achieving perfect precision and recall scores (1.00). It also demonstrated strong performance with COPD, achieving a precision of 1.00, recall of 0.90, and an F1-score of 0.95. Pneumonia was accurately classified with a precision of 0.88, recall of 0.95, and an F1-score of 0.91.While the model showed some limitations with URTI and Healthy cases, the precision for Healthy cases was 0.68 and recall for URTI was 0.67, which affected their F1-scores. Despite these challenges, particularly in addressing overlapping acoustic features, the model proved to be highly effective at detecting critical respiratory diseases, highlighting its potential as a reliable tool for early clinical diagnosis.



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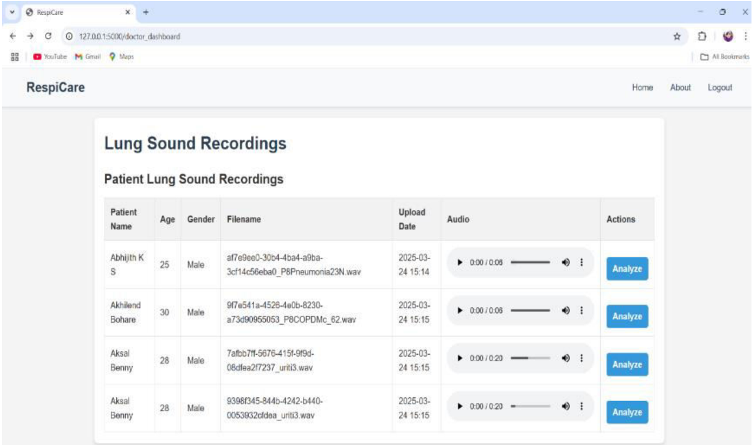

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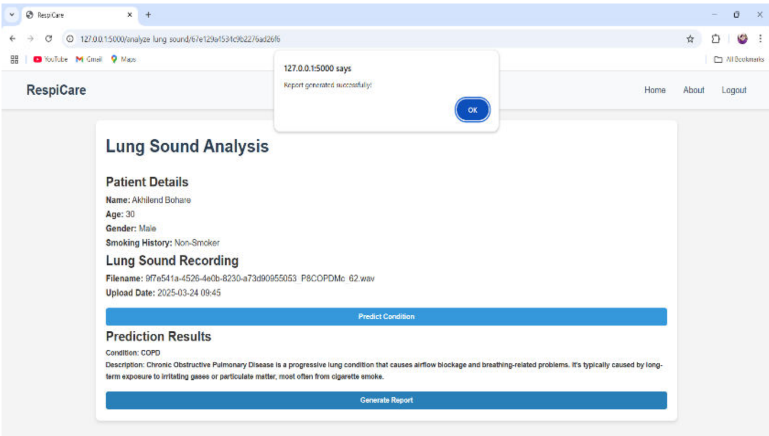

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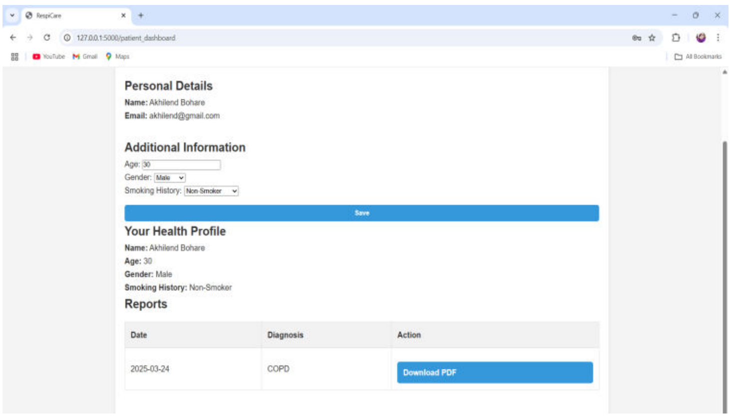

(d)

Fig. 2. Shows the result of result of respiratory disease classification using lung sounds CNN-GRU (a)Lab dashboard, (b)Doctor dashboard, (c)Doctor result analysis,(d)Patient dashboard

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V. CONCLUSION

The developed system effectively categorizes lung sound recordings into different respiratory conditions, achieving a 90% accuracy rate. By utilizing CNN and GRU models, the system effectively learns both spatial and temporal characteristics of lung sound signals, leading to improved classification performance. Compared to LSTM models, GRUs demonstrate superior efficiency, making them more suitable for handling smaller datasets while reducing the risk of vanishing gradient issues. The results highlight the model's ability to differentiate between COPD, Pneumonia, Bronchiolitis, URTI, and Healthy cases, establishing its reliability in respiratory disease diagnosis. The model's high accuracy, recall, and precision scores further confirm its potential for medical applications. Previous studies support the superiority of GRU over LSTM in performance and efficiency. " A study published in Sensors in 2022 utilized a CNN-LSTM model for lung sound classification, achieving an accuracy of 73.69%".The improved accuracy of our CNN-GRU approach underscores its advantage in feature extraction and classification.

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