PREDICTING THE SEVERITY OF PULMONARY DISEASE FROM RESPIRATORY LUNG SOUNDS USING MACHINE LEARNING ALGORITHMS

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Keywords:

Respiratory diseases, Computerized Respiratory Sound Analysis, Mel Frequency Cepstral Coefficients (MFCCs), VGG16 model, early disease detection.

Introduction:

Respiratory diseases like COPD, asthma, and pneumonia affect millions globally and pose serious health risks. Early, accurate diagnosis is vital but often hindered by costly, time-consuming traditional methods that require trained professionals. Auscultation, a common diagnostic tool, is limited by subjectivity and variability.

To overcome these challenges, Computerized Respiratory Sound Analysis (CRSA) combined with deep learning has emerged as a promising solution. Models like CNNs and LSTMs can automatically learn features such as frequency, amplitude, and timing from lung sounds, enabling more accurate, consistent diagnostics.

This project proposes an interactive website that uses deep learning (e.g., VGG16) to classify lung sounds and detect respiratory diseases. Users can upload recordings and receive automated, detailed diagnostic reports. With digital stethoscopes and mobile devices, this non-invasive approach can expand access to respiratory care, especially in remote areas.

Despite challenges like limited datasets and recording noise, the integration of AI holds great promise for advancing pulmonary diagnostics and improving patient outcomes.

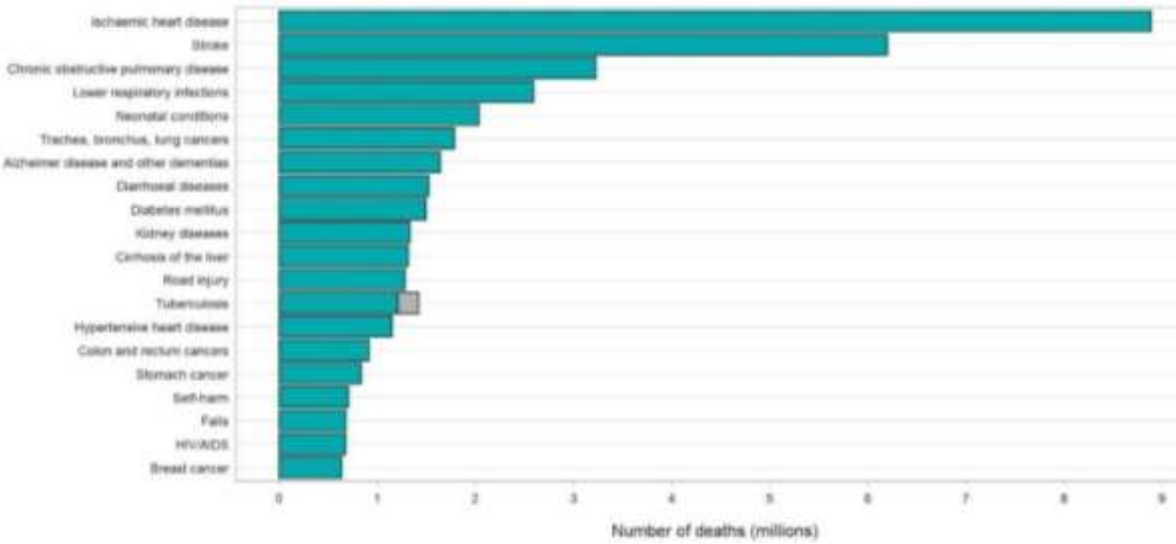


Fig 1 Death Rate

The fig 1.1 shows the population of death rate due to different diseases in the world-by-World Health Organisation.

Objectives:

1. Develop an interactive website for detecting pulmonary diseases from lung sound recordings.
2. Provide a user-friendly interface for easy uploading of recordings and clear result presentation.
3. Implement a robust and accurate system for identifying pulmonary diseases.
4. Generate detailed reports summarizing analysis results, including disease probabilities and insights also it Include a feedback mechanism to improve functionality and user experience.

Methodology:

The proposed system uses a combination of signal processing and deep learning to detect and assess pulmonary diseases from lung sound recordings.

Step 1: Data Collection: Record lung sounds using an electronic stethoscope.

Step 2: Storing Raw Audio Files: Save the collected lung sounds as raw audio files for processing.

Step 3: Denoising Audio Files: Pre-process the raw audio files to remove noise and obtain clean audio data.

Step 4: Spectrogram Conversion: Convert the denoised audio files into:

1. Log Mel Spectrograms
2. MFCC Spectrograms

Step 5: Feature Extraction: Use the VGG16 model to extract features and identify patterns from the spectrograms.

Step 6: Model Training: Train a model combining CNN (via VGG16) for spatial features and LSTM for temporal patterns.

Step 7: Model Saving: Save the trained model for future use in deployment.

Step 8: Classification: Classify lung sounds into one of the eight pulmonary disease categories: Healthy, Pneumonia, Asthma, Lung Fibrosis, COPD, URTI, Bronchiectasis, Bronchiolitis.

Step 9: Deployment: Deploy the trained model on an interactive and user-friendly platform.

Step 10: Data Upload by Users: Allow users to upload their lung sound recordings for analysis.

Step 11: Real-time Analysis: Analyze the uploaded lung sounds using the trained model.

Step 12: Report Generation: Generate a comprehensive diagnostic report with classification results and insights.

Step 13: Feedback Collection: Collect user feedback to refine and enhance the system's performance.

Step 14: End-to-End Solution: Provide an integrated solution for pulmonary disease detection and management.

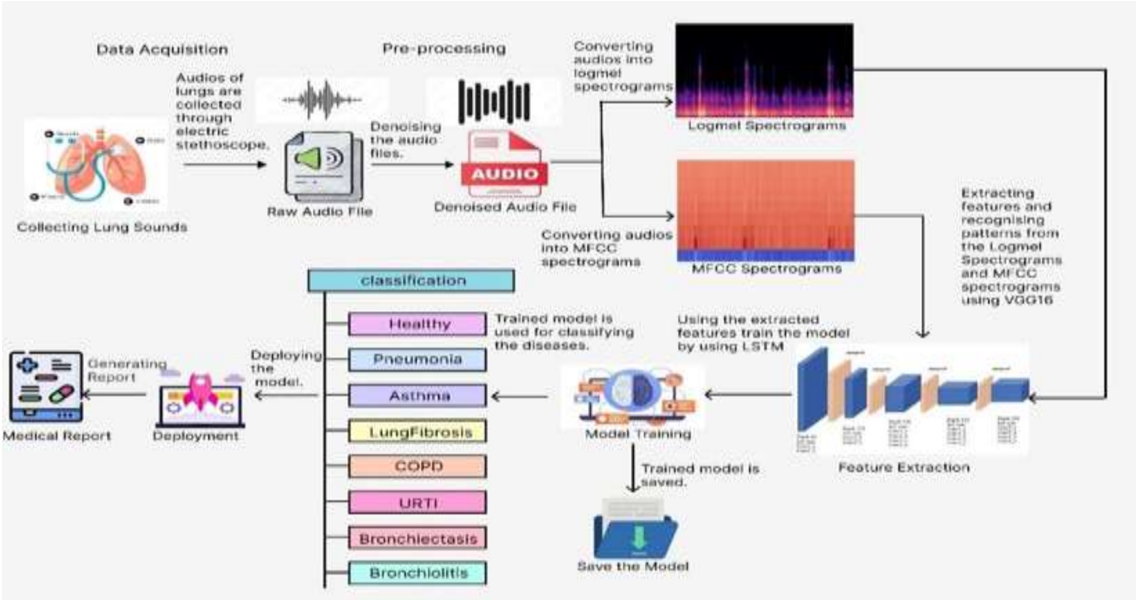


Fig 2 Methodology

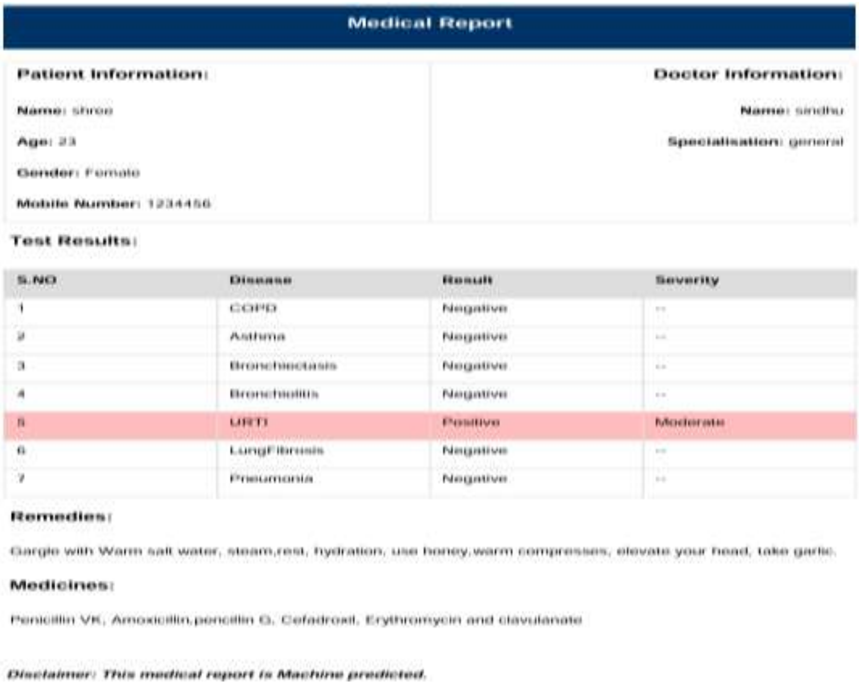
Results & Conclusions

The homepage for detecting pulmonary diseases is designed with a simple and intuitive interface, prioritizing user-friendliness. Navigating through the website is effortless, allowing users to access the displayed data easily, as illustrated in fig

Fig 3 Homepage

The Basic details of the user is entered with the correct email id so that the report can be sent through the email for the user reference, which reduces the time and report is digitally generated.

The audio file of the user is uploaded and the initial raw audio file has been subjected to preprocessing, wherein noise has been eliminated using a band-pass filters and the report has been sent to their mail id.



Medical Report

Patient Information:

Name: shree

Age: 23

Gender: Female

Mobile Number: 1234456

Doctor Information:

Name: sindhu

Specialisation: general

Test Results:

S.NO	Disease	Result	Severity
1	COPD	Negative	--
2	Asthma	Negative	--
3	Bronchiectasis	Negative	--
4	Bronchiolitis	Negative	--
5	URTI	Positive	Moderate
6	LungFibrosis	Negative	--
7	Pneumonia	Negative	--

Remedies:

Gargle with Warm salt water, steam,rest, hydration, use honey,warm compresses, elevate your head, take garlic.

Medicines:

Penicillin VK, Amoxicillin,pencillin G, Cefadroxil, Erythromycin and clavulanate

Disclaimer: This medical report is Machine predicted.

Fig 4 Medical Report

This project focused on accurately classifying pulmonary diseases and predicting their severity using advanced machine learning techniques. By combining VGG16 for feature extraction and LSTM for classification, the system improves upon traditional diagnostic methods, offering a reliable and user-friendly tool for clinical use.

Project Outcomes & Industry Relevance

The project successfully developed an intelligent, non-invasive system for detecting and classifying pulmonary diseases using lung sound analysis. It resulted in the creation of a functional interactive website where users can easily upload respiratory audio recordings and receive real-time diagnostic feedback. The system demonstrated accurate disease classification by leveraging deep learning models like

VGG16 and LSTM, effectively identifying respiratory patterns such as wheezing, crackles, and other abnormalities.

A major outcome is the generation of comprehensive diagnostic reports, which provide users with detailed insights into potential pulmonary conditions and their severity. The project also serves as a demonstration of machine learning effectiveness in the biomedical domain, showing how advanced models can outperform traditional diagnostic methods. Furthermore, a continuous improvement mechanism through user feedback ensures the system evolves to meet user needs more efficiently over time.

This has significant real-world applications, especially in telemedicine, rural healthcare, and early screening programs. In the healthcare industry, this tool can assist doctors in making quicker and more consistent diagnoses, reducing dependence on traditional, time-consuming methods. It also holds potential for integration into smart stethoscopes and mobile diagnostic kits, enhancing point-of-care diagnostics. By reducing cost and increasing accessibility, the project contributes to both the field of biomedical AI and the healthcare sector, offering a scalable solution for respiratory health management.

Working Model vs. Simulation/Study

This project primarily focused on building a functional software-based working model rather than a physical or hardware prototype. The system is implemented as a fully interactive web-based application that processes lung sound recordings uploaded by users and provides real-time diagnostic feedback.

The core components including noise reduction, feature extraction using log-Mel spectrograms and MFCCs, classification through deep learning models (VGG16, LSTM, CNN), and severity prediction using K-means clustering were fully implemented and tested using real-world datasets like the ICBHI and KAUH lung sound databases. This ensures that the system goes beyond a theoretical framework or simulation.

The model has been validated through performance metrics such as accuracy, precision, recall, and F1-score, indicating its readiness for practical deployment. The frontend, built using Streamlit, offers a user-friendly interface that mimics a real clinical use case, allowing users to interact with the system much like they would with a healthcare platform.

Although no physical device (such as a custom-built stethoscope) was developed, the software model is designed to seamlessly integrate with existing medical devices like digital stethoscopes and mobile diagnostic kits. This makes it highly adaptable for use in clinical environments, telemedicine, or rural healthcare setups.In summary, the project delivers a complete working model in software form, with real-world application potential, rather than being limited to a conceptual simulation or theoretical study.

Project Outcomes and Learnings

1. **Functional Interactive Website**: Developed a fully operational web application that allows users to upload lung sound recordings and receive diagnostic results.
2. **Accurate Disease Classification**: Achieved precise classification of various pulmonary conditions such as asthma, COPD, pneumonia, and others using deep learning models (CNN, LSTM, VGG16).
3. **Comprehensive Diagnostic Reports**: Generated detailed, automated reports that provide both classification results and severity levels based on K-means clustering.
4. **Demonstration of Machine Learning Effectiveness**: Validated the performance of the AI models through real-world datasets using metrics like accuracy, precision, recall, and F1-score.
5. **Continuous Improvement**: Incorporated user feedback mechanisms to enable iterative enhancement of the system's accuracy, usability, and reliability.

Through this project, we gained hands-on experience in working with biomedical datasets, deep learning architectures, and audio signal processing. We learned how to handle data noise, apply feature engineering, and optimize model performance. Additionally, integrating backend models with a frontend interface helped us understand the importance of user-centric design in healthcare applications. The project also strengthened our problem-solving, debugging, and collaborative skills while offering insight into the real-world applicability of AI in medical diagnostics.

Future Scope

The project demonstrates promising potential in the early detection and severity prediction of pulmonary diseases through non-invasive analysis of lung sounds. However, there are several areas where the system can be further enhanced and expanded. Future developments and research directions include:

1. **Integration with Electronic Health Records (EHR):** Enable seamless synchronization with hospital EHR systems to automatically update patient diagnostics and support longitudinal health tracking.
2. **Mobile Application Development:** Create a lightweight mobile app version for easier access in remote and rural areas with limited healthcare infrastructure.
3. **Multilingual Support and Accessibility:** Add voice-guided features and support for multiple languages to cater to diverse user groups, including the elderly and visually impaired.
4. **Real-Time Monitoring and Alerts:** Integrate wearable or IoT-based stethoscope devices to continuously monitor respiratory health and send real-time alerts to patients or doctors.
5. **Clinical Validation and Deployment:** Collaborate with healthcare institutions to clinically validate the system's accuracy and integrate it into routine diagnostic workflows.