"Diagnosing Respiratory Conditions Via Lung Sounds using CNN-LSTM"

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Abstract :- In this project, we developed an easy-to-use and affordable algorithm to analyze respiratory sounds, which can be used on any device. The goal was to classify different types of breathing sounds using machine learning techniques. We used two types of features to represent the sounds: Gammatone Cepstrum Coefficients (GTCC) and Short-Time Fourier Coefficients (STFC). These features help the system understand the characteristics of the sounds. The algorithm then uses a combination of a Convolutional Neural Network (CNN) and a Long Short-Term Memory (LSTM) network to classify the sounds accurately.We created four datasets to train and test the algorithm. These datasets include: Healthy versus pathological sounds (to distinguish between normal and abnormal breathing), Classification of different types of sounds, like rales, rhonchi, and normal breath sounds, Classification of individual types of respiratory sounds, and A complete classification that includes all types of breathing sounds. The algorithm is designed to be simple, cost-effective, and can work on various devices, making it accessible for a wide range of users, including healthcare professionals, researchers, or anyone interested in analyzing respiratory sounds.

Keywords:-Respiratory Sound Analysis, Breathing Sound Classification, Gammatone Cepstrum Coefficients (GTCC), Short-Time Fourier Coefficients (STFC), CNN (Convolutional Neural Networks) LSTM (Long Short-Term Memory),Machine Learning, Healthcare Applications,

Introduction :- Respiratory sounds, provide valuable insights into lung health and can help diagnose conditions like asthma, pneumonia, and COPD. Traditionally, diagnosis requires expert interpretation, but machine learning has made automated analysis of ealthcarelung sounds feasible. This study explores the use of Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks for classifying respiratory sounds. CNNs efficiently detect patterns in the audio, while LSTMs capture the temporal relationships in sequential data. By combining these techniques, the proposed system offers a cost-effective, non-invasive method for diagnosing respiratory conditions, aiding h professionals in early detection and monitoring.

Literature survey:-

1] Liqun Wu and Ling Li (2024) proposed a framework combining Random Forest classifier and Empirical Mode Decomposition (EMD) method for multi-classification of respiratory diseases using adventitious respiratory sounds (ARSs). Their system achieved a classification accuracy of 88% and focused on 6 respiratory conditions: healthy, bronchiectasis, bronchiolitis, COPD, pneumonia, and URTI. The study emphasized the importance of segmentation in accurate classification, with the best performance achieved using a combination of early inspiratory and entire inspiratory phases.

[2] B. M. Rocha et al. (2024) presented a respiratory sound database developed for automated classification systems. The database includes 920 recordings from 126 subjects and contains annotations for various types of adventitious respiratory sounds, such as crackles and wheezes. This dataset, gathered from clinical and non-clinical environments, includes noisy recordings, making it suitable for developing algorithms that work under real-life conditions. The study aims to advance respiratory sound analysis by providing a publicly available resource for algorithm development and testing.

[3] Yoonjoo Kim et al. (2024) developed a deep learning model using Convolutional Neural Networks (CNNs) to classify respiratory sounds (normal, crackles, wheezes, rhonchi). The model achieved an accuracy of 86.5% in detecting abnormal sounds, with an AUC of 0.93. It further classified abnormal sounds into crackles, wheezes, or rhonchi with an accuracy of 85.7%. The study also highlighted the varying diagnostic accuracy among medical professionals, demonstrating the potential for deep learning systems to complement clinician auscultation in diagnosing respiratory diseases.

[4] Zhaoping Wang and Zhiqiang Sun (2024) investigated the impact of various parameters on deep learning model performance for lung sound classification. Using the ICBHI 2017 dataset, the authors analyzed the effect of frame length, overlap percentage, and feature types (spectrogram and Mel-frequency cepstrum coefficients) on classification accuracy. The study concluded that a higher overlap percentage (OP) improves performance, with the optimal configuration being a frame size of 128, 75% OP, and spectrogram features, under a fixed sampling frequency of 8 kHz.

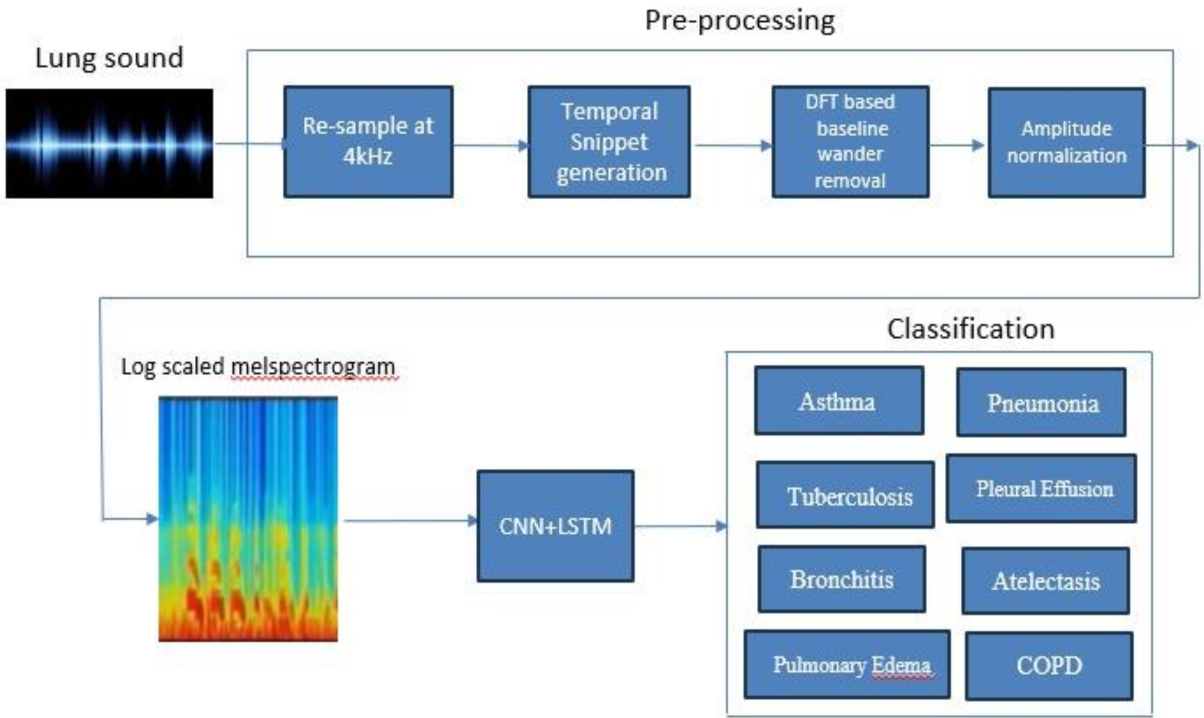
[5] Rajesh Kumar Tripathy et al. (2024) proposed an automated method for detecting pulmonary diseases (PDs) using lung sound signals and fixed-boundary-based empirical wavelet transforms. The model achieved high classification accuracy for differentiating between normal lung sounds and various pulmonary diseases, such as asthma, pneumonia, and COPD. Using the Light Gradient Boosting Machine (LGBM) classifier, the study demonstrated improved detection rates, with an overall accuracy of 84.76% for the multi-class classification scheme involving normal, pneumonia, asthma, and COPD.

Models and methodology :-

Evaluation:-Compare the model against existing methods such as MFCC-Inception networks.Analyze the classification accuracy across various lung diseases like asthma, pneumonia, COPD, etc.

Feature Extraction:-Extract Gammatone Cepstrum Coefficients (GTCC) and Short-Time Fourier Coefficients (STFC) from audio recordings.
These features provide significant insights into sound patterns relevant to lung condition diagnosis.

Model Design:-Implement a hybrid CNN-LSTM architecture:
CNN layers to extract spatial features from the sound spectrograms.
LSTM layers to capture temporal patterns in the lung sound sequences.
The model aims to optimize accuracy while being lightweight and computationally efficient.



Respiratory conditions are diagnosed through spirometry and lung auscultation. Spirometry is measuring the volume of air mobilized in respiration. Even though, this method is one of the most commonly available lung function tests and well validated for the diagnosis and monitoring of upper and lower airway abnormalities , it is limited to patient's cooperation and therefore, is error prone. Moreover, traditional spirometers are normally used only in clinical settings due to their high cost and required calibration along with challenges in patient guiding. Auscultation is other technique which involves listening to the internal human body sounds with the aid of a stethoscope and typically performed on the anterior and posterior chest. From past few years, it has been an effective tool to understand lung disorders and possible abnormalities. However, this process is limited to physicians as they are well trained. For various reasons like faulty instrument or noisy environment, false positives can happen. Therefore, it opens a door to develop comput- erized lung sound analysis tools/techniques, where automation is the integral part.

Conclusion :-

Looking at the audio content, it is difficult to classify respiratory sounds. In our research, a system is presented for distinction of healthy and non-healthy lung sounds which is very important prior to further diagnosis of the type and severity of infection. We have performed our experiments using a publicly available dataset and evaluations indicate that the highest accuracy of 99.22 with an AUC value of 0.9993 is obtained.Automated adventitious sounds detection or classification provides a promising solu- tion to overcome the limitations of conventional auscultation. In future the subject area for future investigation will be: To use larger dataset and test further on robustness in presence of higher percent- ages of noise.Attempts will also be made towards isolation of breath sounds from the ambient noises and heart- beat sounds for better analysis. Other acoustic techniques will be applied for even better modelling of the lung sounds along with deep learning-based approaches.To have clinical use in pulmonary health screening and as a tool in differential diag- nosis of pulmonary diseases.Finally, we will be trying to identify the nature and severity of infection from the breath sounds.

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