IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.102 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 5, May 2024

DOI: 10.17148/IJARCCE.2024.13573

Asthma Recognition System Using Lung Sound

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Abstract: Asthma, a prevalent chronic respiratory disorder, affects millions worldwide, necessitating accurate and timely diagnosis for effective management. Recent advancements in artificial intelligence (AI) have facilitated the development of non-invasive diagnostic tools, particularly in analyzing respiratory sounds. In this paper, we propose a novel asthma recognition system utilizing Convolutional Neural Networks (CNNs) and Long Short-Term Memory networks (LSTMs) for analyzing respiratory sound data.

The proposed system begins by preprocessing raw respiratory sound recordings to extract relevant features. These features are then fed into a CNN-LSTM architecture, which effectively captures both spatial and temporal dependencies in the data. The CNN component learns hierarchical feature representations from spectrogram-like input representations of respiratory sound, while the LSTM component learns temporal patterns and dependencies. We conduct experiments on publicly available respiratory sound datasets to evaluate the performance of the proposed system. We compare our approach with existing methods and demonstrate its superior performance in terms of accuracy, sensitivity, and specificity in asthma recognition.

Furthermore, we analyze the interpretability of the CNN-LSTM model to provide insights into its decision-making process, enhancing its trustworthiness in clinical applications. Additionally, we discuss the scalability and deployment feasibility of the proposed system in real-world healthcare settings.

Our findings suggest that the CNN-LSTM-based asthma recognition system offers a promising avenue for accurate and automated asthma diagnosis using respiratory sound data. By leveraging deep learning techniques, this system has the potential to improve diagnostic accuracy, reduce healthcare costs, and enhance patient care in asthma management.
patients.

Key Words: Asthma, Respiratory Sound, Healthcare, Machine learning

I. INTRODUCTION

Asthma, a chronic respiratory condition characterized by airway inflammation and hyperresponsiveness, poses a significant global health burden, affecting millions of individuals of all ages. Timely and accurate diagnosis of asthma is crucial for effective management and prevention of exacerbations, yet traditional diagnostic methods often involve invasive procedures and are not readily accessible to all populations. Recent advances in artificial intelligence (AI) and machine learning (ML) techniques have opened new avenues for non-invasive and cost-effective diagnostic tools, particularly in the analysis of respiratory sound data. Respiratory sound analysis offers valuable insights into the pathophysiology of asthma, as the characteristic wheezing, crackles, and other sounds provide indirect indicators of airway obstruction and inflammation. Leveraging AI algorithms to interpret these sounds holds promise for improving diagnostic accuracy and streamlining the diagnostic process. Among various AI architectures, Convolutional Neural Networks (CNNs) and Long Short-Term Memory networks (LSTMs) have emerged as powerful tools for learning complex patterns and dependencies in sequential data, making them well-suited for analyzing respiratory sound recordings.

In this context, this paper proposes a novel asthma recognition system that combines CNNs and LSTMs to analyze respiratory sound data for automated diagnosis. By integrating spatial and temporal information from respiratory sound recordings, the proposed system aims to capture intricate patterns indicative of asthma, thus facilitating accurate and timely diagnosis. Through comprehensive experiments and evaluations on publicly available datasets, the efficacy of the CNN-LSTM-based approach is assessed, comparing its performance against existing methods.

Moreover, beyond its diagnostic capabilities, the interpretability of the CNN-LSTM model is investigated to enhance its transparency and trustworthiness in clinical applications. Scalability and deployment considerations in real-world healthcare settings are also discussed, emphasizing the potential of AI-driven diagnostic systems to improve patient care and healthcare outcomes.

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In summary, this paper contributes to the growing body of research on AI-based diagnostic tools for asthma recognition, demonstrating the potential of deep learning techniques to revolutionize respiratory healthcare. By harnessing the power of AI, we aim to advance the field of asthma diagnosis, ultimately improving the quality of life for asthma patients worldwide

1. Data Collection and Preprocessing:

- Identify and collect respiratory sound datasets containing recordings from individuals with and without asthma.
- Preprocess the raw sound data to remove noise, normalize amplitude, and extract relevant features, such as spectrograms or Mel-frequency cepstral coefficients (MFCCs).
- Split the data into training, validation, and test sets to facilitate model development and evaluation.

2. Model Architecture Design:

- Design a CNN-LSTM architecture suitable for analyzing sequential data like respiratory sound recordings.

The CNN component extracts hierarchical feature representations from the spectrogram-like input representations of respiratory sounds.

The LSTM component captures temporal patterns and dependencies in the sequential data.

3. Training:

Initialize the parameters of the CNN-LSTM model.

Train the model using the training data, optimizing a chosen loss function (e.g., binary cross-entropy) with a suitable optimization algorithm (e.g., stochastic gradient descent or Adam).

Tune hyperparameters, such as learning rate, batch size, and regularization techniques, to optimize model performance.

4. Evaluation:

- Evaluate the trained model on the validation set to monitor performance during training and adjust hyperparameters if necessary.
- Assess the model's performance on the test set using metrics such as accuracy, sensitivity, specificity, and area under the receiver operating characteristic curve (AUC-ROC).
- Compare the performance of the CNN-LSTM model against baseline models and existing methods to demonstrate its effectiveness in asthma recognition.

5. Interpretability Analysis:

- Employ interpretability techniques, such as saliency maps or attention mechanisms, to analyze the CNN-LSTM model's decision-making process.
- Identify which parts of the respiratory sound recordings are most influential in determining the presence of asthma, enhancing the model's transparency and trustworthiness in clinical settings.

By following this methodology, the project aims to develop and evaluate a CNN-LSTM-based asthma recognition system using respiratory sound data, with the ultimate goal of improving asthma diagnosis and patient care.

II. LITERATURE SURVEY

1. Respiratory diseases recognition through respiratory sound with the help of deep neural network

In this research paper, they have discussed how deep learning could be used in the recognition of respiratory disease just from the respiratory sound. Prediction of respiratory diseases such as COPD(Chronic obstructive pulmonary disease), URTI(upper respiratory tract infection), Bronchiectasis, Pneumonia, Bronchiolitis with the help of deep neural networks or deep learning. In This Research Paper They have constructed a deep neural network model that takes in respiratory sound as input and classifies the condition of its respiratory system. It not only classifies among the above-mentioned disease but also classifies if a person's respiratory system is healthy or not with higher accuracy and precision

2. AI Sound Recognition on Asthma Medication Adherence: Evaluation with the RDA Benchmark Suite

This paper presents an extensive review and discussion on the state of the art methods and tools for acoustic analysis

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and content-based audio classification of inhaler sounds on medication adherence, which could be used to improve the techniques on aerosol therapy. they try to cover a large part of the existing material, so all points of interest need to be included, to capture from one corner of the topic to the current status of the research and make the research of broad interest, but focusing only on inhaler's and respiratory sounds Their research includes articles that use classical algorithms and machine learning approaches for acoustic signal analysis, detection and recognition.

The state of the art begins with methods from 2010, which mainly use decision trees as a technique for the identification of the signal and continues with supervised learning methods, aiming to classify respiratory sounds, obtained from pMDIs. This scientific sub-field is referred as "sound analysis, detection and recognition"

3. Classify Respiratory Abnormality in Lung Sounds Using STFT and a Fine-Tuned ResNet18 Network

Recognizing patterns in lung sounds is crucial to detecting and monitoring respiratory diseases. Current techniques for analysing respiratory sounds demand domain experts and are subject to interpretation. Hence an accurate and automatic respiratory sound classification system is desired. In this work, we took a data-driven approach to classify abnormal lung sounds.

We compared the performance using three different feature extraction techniques, which are short-time Fourier transformation (STFT), Mel spectrograms, and Wav2vec, as well as three different classifiers, including pre-trained ResNet18, Light CNN, and Audio Spectrogram Transformer. Our key contributions include the bench-marking of different audio feature extractors and neural network based classifiers, and the implementation of a complete pipeline using STFT and ane-tuned ResNet18 network. The proposed method achieved Harmonic Scores of 0.89, 0.80, 0.71, 0.36 for tasks 1-1, 1-2, 2-1 and 2-2, respectively on the testing sets in the IEEE BioCAS 2022 Grand Challenge on Respiratory Sound

4. Towards using cough for respiratory disease diagnosis by leveraging Artificial Intelligence

Cough acoustics contain multitudes of vital information about pathomorphological alterations in the respiratory system. Reliable and accurate detection of cough events by investigating the underlying cough latent features and disease diagnosis can play an indispensable role in revitalizing the healthcare practices. The recent application of Artificial Intelligence (AI) and advances of ubiquitous computing for respiratory disease prediction has created an auspicious trend and myriad of future possibilities in the medical domain. In particular, there is an expeditiously emerging trend of Machine learning (ML) and Deep Learning (DL)-based diagnostic algorithms exploiting cough sign atures.

The enormous body of literature on cough-based AI algorithms demonstrate that these models can play a significant role for detecting the onset of a specific respiratory disease. However, it is pertinent to collect the information from all relevant studies in an exhaustive manner for the medical experts and AI scientists to analyse the decisive role of AI/ML. This survey offers a comprehensive overview of the cough data-driven ML/DL detection and preliminary diagnosis frameworks, along with a detailed list of significant features. We investigate the mechanism that causes cough and the latent cough features of the respiratory modalities. We also analyse the customized cough

III. AIM & OBJECTIVES

1. Develop an AI-based asthma recognition system using respiratory sound analysis.
2. Utilize a CNN-LSTM architecture to enhance the accuracy and efficiency of asthma diagnosis.
3. Improve accessibility to asthma diagnosis through non-invasive and cost-effective AI-driven methods.
4. Provide a novel approach to automate asthma recognition, aiding in timely intervention and management.
5. Enhance the effectiveness of asthma diagnosis by leveraging deep learning techniques on respiratory sound.
6. Utilize deep learning techniques to automate asthma recognition from respiratory sound data.
7. Improve diagnostic accuracy and efficiency through non-invasive AI-driven methods.
8. Enhance accessibility to asthma diagnosis by leveraging cost-effective technology.
9. Validate the effectiveness of the system through rigorous experimentation and evaluation.
10. Provide a reliable tool for early intervention and management of asthma patients.

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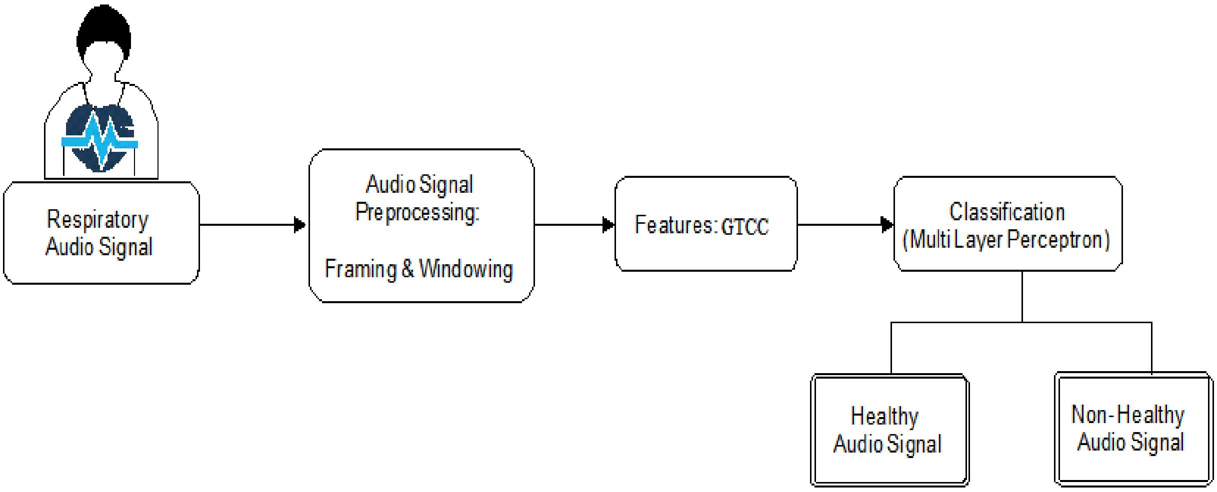
IV. SYSTEM ARCHITECTURE



a. APPLICATION

The Missing Person Search system can be used in following areas:

1. Clinical diagnosis and monitoring in healthcare facilities.
2. Telemedicine and remote monitoring platforms.
3. Integration into home healthcare devices for self-monitoring.
4. Public health screening programs for asthma risk assessment.
5. Research and development for clinical trials and drug development.
6. Health education and awareness initiatives.
7. Occupational health monitoring for workplace safety.
8. Emergency response and disaster management protocols.

b. LIBRARIES AND SERVICES USED

i. **Flask:-** Flask is a lightweight and open- source web framework for Python that allows developers to quickly build web applications. In this application, flask is extensively used to develop the web-based administrator portal for the application.

ii. **TensorFlow / Keras:** TensorFlow is an open-source machine learning framework developed by Google, often used for building neural networks. Keras is a high-level neural networks API that runs on top of TensorFlow, making it easier to define and train deep learning models.

iii. **PyTorch:** Another popular open-source deep learning framework, PyTorch offers flexibility and ease of use, particularly for dynamic computational graphs. It provides tools for building and training neural networks efficiently.

iv. **Librosa:** Librosa is a Python library for audio and music analysis. It provides functions for loading audio files, extracting features (e.g., spectrograms, MFCCs), and preprocessing audio data, which are essential for analyzing lung sound recordings.

v. **Pandas:** Pandas is a versatile data manipulation library in Python, commonly used for handling tabular data. It can be employed for organizing respiratory sound datasets, performing data preprocessing, and preparing data for model training.

vi. **Scikit-learn:** Scikit-learn is a comprehensive machine learning library in Python, offering tools for data preprocessing, model selection, evaluation, and more. While it may not be directly used in training CNN-LSTM models, it can be helpful for preprocessing data or evaluating model performance.

vii. **Jupyter Notebooks:** Jupyter Notebooks are interactive web-based environments for writing and executing code, visualizing data, and documenting workflows. They are commonly used for exploratory data analysis, prototyping models, and sharing research findings.

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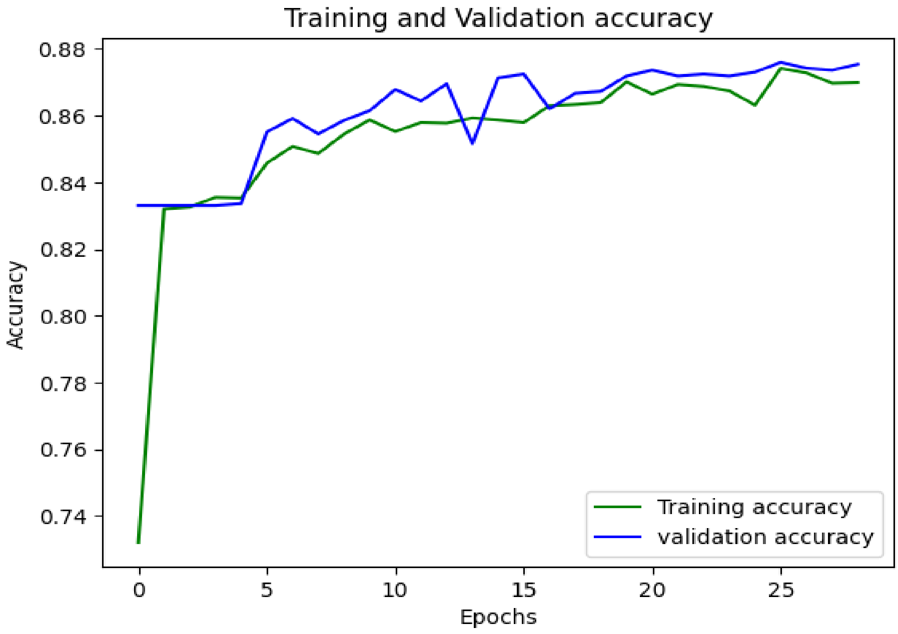
c. **Anaconda:** Anaconda is an open-source distribution of the Python and R programming languages, as well as a comprehensive collection of data science and machine learning libraries. It is designed to simplify package management and deployment, making it an ideal choice for data scientists, researchers, and developers working on projects involving data analysis, machine learning, and scientific computing.

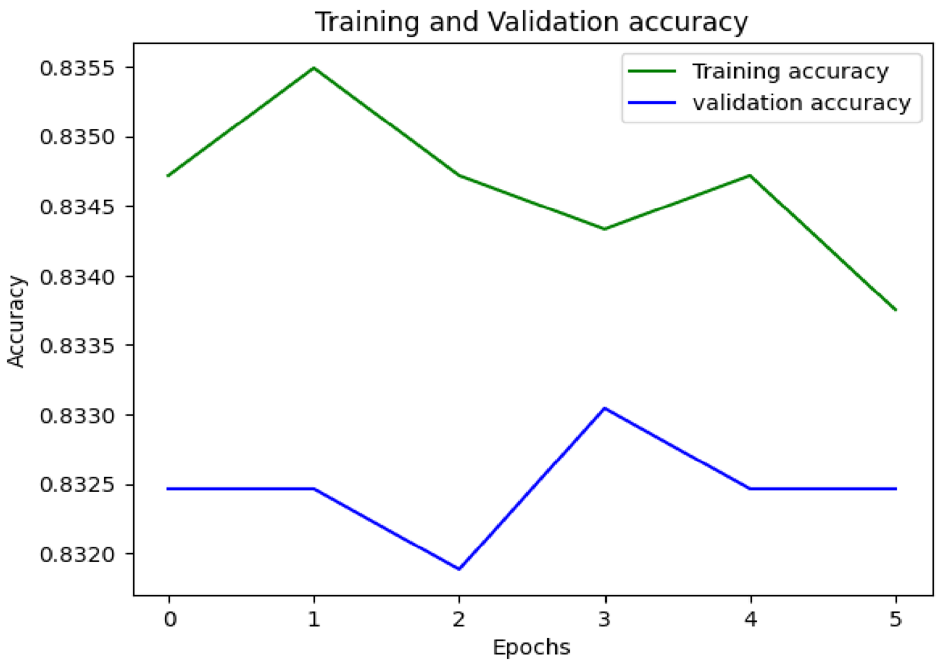
VII. RESULTS

I. Accuracy of Models

A. Training and Validation Accuracy for MFCC Model



B. Training and Validation Accuracy for Chroma Model



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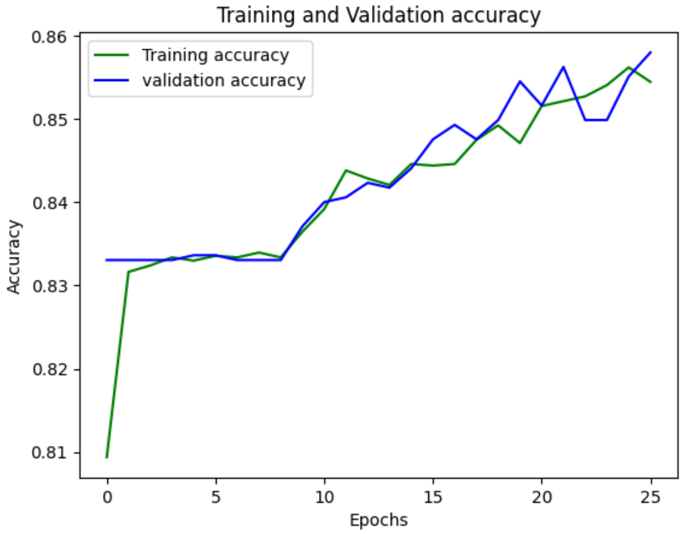
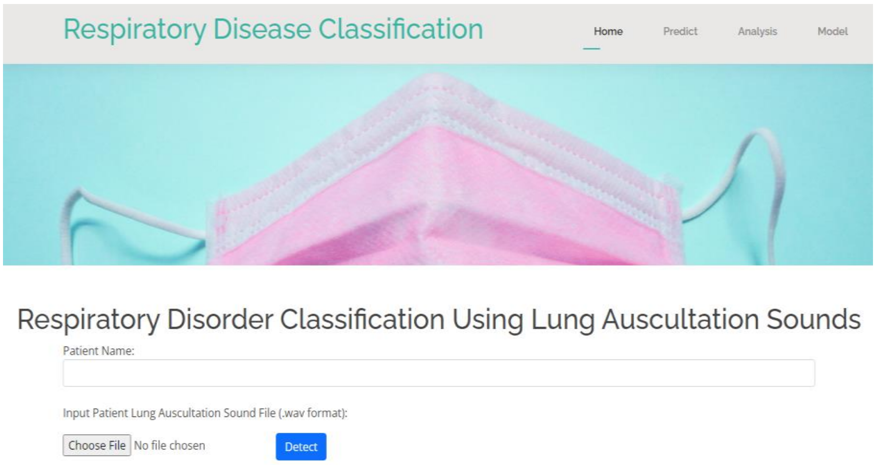
C. Training and Validation Accuracy for MSPEC Model:

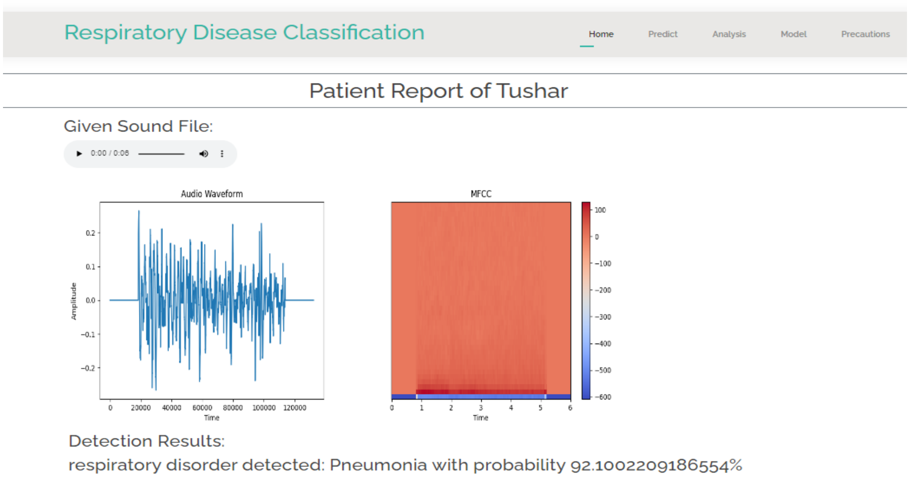


II. User Interface For The Giving Lung Sound Input:

The user can give input to the sytems using web application the user will have to enter the name and sample of their lung sound



III. Final output of the patient for the given lung sound:



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VIII. SYSTEM REQUIREMENTS

Hardware Requirements:

- AMD/Intel i3 Processor or above Processor
- 4GB RAM or above RAM
- 10 GB or above Hard Disk

Software Requirements:

- Windows 8.1 or above
- HTML
- JavaScript
- CSS
- PYTHON
- Anaconda
- JupyterLab

IX. CONCLUSION

the AI-based asthma recognition system utilizing lung sound analysis presents a groundbreaking approach to asthma diagnosis. Through the integration of machine learning and signal processing, it offers a promising avenue for rapid and accurate identification of asthma-related patterns in lung sounds. While further research and validation are required to optimize its performance and ensure its integration into clinical practice, this technology holds immense potential for enhancing patient care and advancing the field of respiratory medicine."

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