COVID-19 Cough Detection using Deep Learning

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Course: Machine Learning

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Problem Statement

COVID-19 detection methods such as RT-PCR are time-consuming and costly. Cough sounds, being a key respiratory symptom, contain identifiable acoustic patterns that can indicate infection. The aim of this project is to build a machine learning-based system capable of classifying cough audio samples as COVID-19 positive or healthy, providing a fast, non-invasive pre-screening solution.

Approach

The project uses the Coswara dataset (from IISc Leap), which consists of crowd-sourced cough recordings. The approach focuses on extracting a comprehensive set of acoustic features from these recordings and applying a Convolutional Neural Network (CNN) to distinguish between COVID-19 ('non-healthy') and healthy cases.

Implementation Overview

1. Data Preparation

• Downloaded and extracted the public Coswara dataset from GitHub.
• Loaded the metadata and filtered it to include only 'healthy' and 'non-healthy' samples, creating a binary classification problem.
• Mapped audio file paths to the corresponding metadata for each participant.

2. Feature Extraction

• Extracted a rich set of audio features using the Librosa library, including:
 - Mel-Spectrogram (as a 2D image-like representation)
 - MFCCs (Mel-Frequency Cepstral Coefficients)
 - RMS (Energy)
 - Zero-Crossing Rate
 - Spectral Features (Centroid, Bandwidth, Contrast)
 - Pitch
• Combined these features into standardized numerical arrays using NumPy.

3. Model Training and Evaluation

• Applied MinMaxScaler for feature normalization, scaling the data to a range between 0 and 1.
• Trained a Convolutional Neural Network (CNN) using TensorFlow/Keras.
• Evaluated the model using Accuracy, Precision, Recall, F1-score, the AUC-ROC curve, and a Confusion Matrix.
• Achieved approximately 66% accuracy on the test data.

Conclusions and Challenges

The CNN-based approach demonstrated a moderate ability to differentiate between healthy and non-healthy coughs based on the extracted acoustic features. While the overall accuracy was around 66%, the model showed a high specificity of 0.84, indicating it was effective at correctly identifying healthy individuals.

The main challenge was the model's low recall of 0.46 for the 'non-healthy' class. This was likely due to the high acoustic variance within the non-healthy category, which included multiple conditions (e.g., positive_mild, positive_moderate, resp_illness_not_identified). This resulted in a high number of false negatives, where the model incorrectly classified sick individuals as healthy.

Future work could involve using more advanced deep learning models to better capture temporal dependencies in the audio and deploying the model in a mobile app for real-time detection.