Methodology:

1. Data Collection and Preprocessing:

Cough Sound Data:

Gathered some data on Cough Sound from some group of people, such as adult and child patients in various sectors, like, hospitals, home and noisy public places.

We included 126 cough sounds of 30 patients for the first study. In 30 patients, there are 15 pneumonia and 15 non-pneumonia patients. Also supplemented with additional datasets for second study. Data augmentation techniques, including time-axis warping, amplitude scaling and spatial impulse are applied to generate more variable and error free datasets.

Noise Filtration:

Advanced noise removal algorithms have been applied to demarcate cough sound from background noises to provide quality input data to the model.

1. Feature Extraction:

Raw audio is refined and converted it to 2D images depicting time, frequency, and amplitude so that the frequency patterns which are related to pneumonia could be identified for the model.

Gramian Angular Fields (GAF):

The waves of cough sound has been transformed to images which are contain with temporal and frequency based characteristics.

To construct a 3D dataset Mel Spectrograms are used that preserve more feature aspects.

Psychoacoustic Features:

To evaluate the strength and spectral change in cough sounds loudness and energy ration has been captured.

1. **Hybrid CNN-LSTM Model:**

**CNN (Convolutional Neural Network**): 2D and 3D images of cough sounds, like Mel Spectrograms and GAF, to capture important patterns and details.

**LSTM (Long Short-Term Memory):** The timing and patterns of cough sounds are analyzed to understand long-term changes in the data. The hybrid model performed better at detecting patterns specific to pneumonia.

**Training and Validation:**

The model is trained using a dataset of 43000 augmented cough sounds.

The model achieved 99.5% accuracy in noisy environments and 97.5% in rectangular rooms, proving its resistance to noise.

1. **Mobile Integration:**

**TensorFlow Lite Framework:** Put the lightweight CNN-LSTM model on mobile devices for instant results.

**Flutter-Based Mobile Application:** Created an easy-to-use interface for remote pneumonia diagnosis.

Enabled users to record cough sounds, get instant diagnosis, and monitor their respiratory health over time.