This Project of Digital Signal Possessing

About

ECG (Normal & LBBB)

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1. Preprocessing

Preprocessing prepares the raw ECG signal for further analysis by reducing noise and standardizing the data. The steps are as follows:

- ## Mean Removal

  The mean of the ECG signal is subtracted from each data point to center the signal around zero. This step removes any DC offset in the data.

- ## Bandpass Filtering

  A Butterworth bandpass filter with a frequency range of 0.5 Hz to 40 Hz was applied. This step suppresses both low-frequency noise (e.g., baseline wander) and high-frequency noise (e.g., muscle artifacts).

  Library Used: scipy.signal

  The butter function was used to design the Butterworth filter, while the lfilter function was used to apply it.

  Parameters:

  Filter order: 4 (chosen to balance performance and computational efficiency).

  Frequency range: 0.5 Hz to 40 Hz (optimal for retaining ECG signal components while removing noise).

  - ## Normalization

  The ECG signal was normalized to a standard range to reduce amplitude variability and ensure consistency across different recordings.

  Library Used: numpy

  The numpy library was used for efficient numerical computation.

  Parameters:

  Min-max scaling was applied to bring the signal values within the range [0, 1]. This method was chosen for its simplicity and effectiveness in standardizing data.

2. Feature Extraction

Only the most relevant coefficients are used for classification.

- ### Wavelet Transform:

  Decomposes signals into approximation and detail coefficients using the 'db4' wavelet.

- ### Statistical Features:

  Mean, standard deviation, and energy of the coefficients are computed.

- ### Decomposition Levels

  The ECG signal was decomposed into **9 levels** using the db4 wavelet. Each level represents a specific frequency band:

  Approximation Coefficients: Capture low-frequency trends in the signal.

  Detail Coefficients: Represent higher-frequency variations, including noise and specific ECG features like QRS complexes.

- ### Features Extracted

  - **Energy coefficients** from different wavelet sub-bands.
  - Peak and duration information for the P, QRS, and T waves.
  - Variations in wavelet coefficients indicating specific LBBB patterns.

- ### Visualization of Wavelet Decomposition

  Below is a 9-level wavelet decomposition of an ECG signal using the Daubechies wavelet (db4). Each level captures specific frequency components of the signal

3. Classification

The classification step assigns a label to the processed ECG signal, determining whether it indicates Normal or LBBB.

- Machine Learning Models

  - **K-Nearest Neighbors (KNN)**: Classifies signals based on similarity with neighboring data points.
  - **Decision Tree**: Uses a tree structure to split data based on feature thresholds.
  - **Support Vector Machine (SVM)**: Constructs a hyperplane to separate the two classes (Normal and LBBB).

  - **KNN**: Achieved an accuracy of ~93%.
  - **Decision Tree**: Achieved an accuracy of ~ 94%.
  - **SVM**: Achieved an accuracy of ~ 83%.

(**KNN**) K	**Accuracy**
3	0.9326599326599326
5	0.8484848484848485
7	0.8535353535353535