

**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.

1. **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

1. **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%.

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