EOG UP & DOWN Classification

Name	ID
منة ياسر حامد مصطفى	2022170447
رؤى محمد لطفي محمد علي	2022170162
مايا سامح احمد سمير	2022170340
سارة عبدالحميد عليوه	2022170571

➢ Project Overview

The final project in the Biomedical Signal Processing course involved the development of a classification system designed to detect whether a person's eyes are moving up or down based on EOG (electrooculography) signals. This project was selected due to the significant applications of eye movement detection in human-computer interaction and medical diagnosis, particularly for patients with limited mobility who may use eye movements to control devices.

➢ Implementation Details

1. Signal Preprocessing

Several preprocessing steps were implemented to clean and prepare the EOG signals:

a) <u>Outlier Removal</u>

- Z-scores were used to identify and remove statistical outliers ($|z| > 3$).
- Outliers were replaced with the mean value to maintain signal continuity.
- This process helped eliminate sudden spikes caused by electrode movement or other artifacts.

b) <u>Mean Removal and Filtering</u>

- The DC component (mean) was removed to center the signal around zero.
- A bandpass filter (0.5-20 Hz) was implemented using a 4th-order Butterworth filter.
- These cutoff frequencies were chosen based on literature indicating that most EOG signals fall within this range.

c) <u>Normalization and Resampling</u>

- Min-max normalization was applied to scale signals between 0 and 1.

- The signal was downsampled by 50% to reduce computational overhead.
- Null values were handled by replacing them with zeros.

2. Feature Extraction

Discrete Wavelet Transform (DWT) was used for feature extraction:

- Four Daubechies wavelets (db1-db4) were selected based on their similarity to EOG waveforms.
- Four decomposition levels were employed for capturing signal characteristics:
  - Level 1: High-frequency noise and rapid eye movements.
  - Levels 2-3: Main eye movement components.
  - Level 4: Slow baseline drift.
- Eight statistical features were extracted from each coefficient:
  - Mean and standard deviation for amplitude information.
  - Maximum and minimum for range information.
  - Skewness and kurtosis for distribution shape.
  - Median and interquartile range (IQR) for robust central tendency measures.

3. Classification

K-Nearest Neighbors (KNN) was chosen as the classifier due to its effectiveness for non-linear patterns like EOG signals:

- k=3 neighbors were used to achieve a balance between overfitting and generalization.

- Distance-weighted voting was implemented to give closer neighbors more influence.
- Features were normalized using StandardScaler before classification.
- The model was trained on labeled data for "UP" and "DOWN" movements.

4. User Interface

A graphical user interface (GUI) was developed using tkinter to enhance usability:

- The interface allows users to select training files for up and down movements.
- Provides functionality to train the model and display training accuracy.
- Enables the selection of test files and displays predictions along with confidence scores.

The project encountered several challenges during development:

1. Initially, a larger number of wavelet decomposition levels (6) was attempted, but this introduced excessive noise in the features.
2. Experimentation with different k values (1-7) for KNN revealed that k=3 provided the optimal balance of accuracy and generalization.
3. Adjusting the wavelet decomposition levels had a significant impact on accuracy, with level 4 offering the best balance between feature richness and noise reduction.
4. Edge cases, such as missing values and file loading errors, required careful handling.