General

This assignment requires you to develop a code pipeline to analyze physiological eye-tracking data collected from users. Your task is to demonstrate your capabilities in both signal processing and software engineering. Your final solution should:

- Process the data accurately
- Provide clear visualizations
- Extract meaningful biomarkers
- Include well-structured, maintainable code
- Include basic software engineering practices such as logging and error handling.

Python 3 is required. Please use libraries such as NumPy, Pandas, and matplotlib. You may also use other open-source libraries if needed.

Please submit your project via a GitHub repo or zip file containing all code, figures, and the README.

Background Knowledge

The pupillary light reflex (PLR) is the constriction of the pupil in response to bright light.
In this assignment, you will work with eye-tracking data from subjects exposed to bright light, recorded with a mobile phone camera to measure their PLR.

The Dataset

The dataset provided for this assignment contains a collection of pupillary light reflex (PLR) tests conducted by our app users. In each PLR test, the user looked into the phone camera while their eyes were recorded as the flash illuminated them for about three seconds, eliciting the pupillary light reflex.
Each test includes two files:

- **Landmarks file:** This file contains the positions of 27 eye landmarks for each of the user's eyes, with each landmark representing a specific location on the eye, as specified in the *Landmark Definitions* file (e.g., landmark 8 is the pupil center). This file has the suffix "**_landmarks.csv**"

- **Test protocol file:** This file details the flash onset and offset times for the test. This file has the suffix "**_protocol.csv**"

Both of these files are named using the test ID followed by an underscore and then the suffix, such as **ID_suffix.csv**.
Together, these files provide the data needed to analyze and evaluate a PLR response.

Instructions

Perform the following instructions for each test in the dataset.
Save all figures created for a given test in a folder named after the test ID.
Ensure that figures are clear and informative.
Pay attention to the units and scale of each calculated measure, signal, or biomarker.

1. **Clean Landmarks Data**
   Remove frames where the **retCode** is not OK.

2. **Extract Pupil Size**
   Use **pupil landmarks** to extract the size of the pupil over time for each eye.
   Bonus: Convert the extracted pupil size signal from pixels to millimeters. *Hint:* The iris diameter has low variance across the population and can be assumed to be 11.7 mm.

3. **Signal Quality**
   Come up with a metric to represent the signal quality for a single test and explain your reasoning and observation.

4. **Noise Reduction**
   Reduce noise in the pupil size signal using any method you consider suitable. Describe the technique you chose and explain your reasoning.

5. **Noise Reduction Figure**
   Create a figure showing pupil size over time, both before and after noise reduction. Include the pupil size signal quality measure developed in Stage 2 in the figure's title, showing the measure for both the raw and noise-reduced signals. Did the noise reduction you applied affect the measure as expected?

6. **Blink Detection and Removal**
   Detect and remove blinks from the data. *Hint*: Start by creating a signal indicating how open the eye is, then examine it to identify blink segments and choose a method for removing them. Keep in mind that not all tests will contain blinks.

7. **Calculate Biomarkers for Each Eye**

   - **Constriction Latency:** The reaction time of the pupil to the light (in ms).
   - **Total Constriction:** The amount of pupil constriction from the constriction onset to the point of maximum constriction (in pixels or mm).
   - **Constriction Velocity:** The speed of constriction (in pixels/sec or mm/sec).

   Note: To calculate these features, first determine the "start of constriction".

8. **Pupil Size and Constriction Figure**
   Create a figure showing pupil size over time, the period the light was on, the point you identified as the "start of constriction", and the point of maximum constriction.