**Photoplethysmography (PPG) Signal Acquisition and Analysis Final Exam**

This final exam builds upon your previous lab experiences, integrating key concepts learned throughout the semester to investigate and compare transmissive and reflective photoplethysmography (PPG) sensor methods for measuring heart rate.

**Background**

PPG sensors measure variations in blood volumeA diagram of a transistor mode

AI-generated content may be incorrect. that correspond to heartbeats. These volume changes occur due to pulsatile blood flow, making photoplethysmography (PPG) effective for determining heart rate. The method leverages optical techniques, hence the prefix "photo." Two primary optical measurement methods exist: reflective and transmissive.

Diagram of a diagram showing different types of blood flow

AI-generated content may be incorrect.In the reflective mode, both the light source and detector are positioned side-by-side on the same side of the finger. When the finger is illuminated, a portion of the incident light is absorbed by hemoglobin, some passes through the tissue, and some is reflected. The intensity of the reflected light varies inversely with blood volume; higher blood volumes reduce reflected light intensity, whereas lower blood volumes increase it.

Conversely, the transmissive method places the light source and detector opposite each other, across the fingertip. Here, the detector measures the intensity of the transmitted light, which also fluctuates with changes in blood volume. Higher blood volumes will result in reduced transmitted light intensity, whereas lower blood volumes will increase transmitted intensity.[[1]](#footnote-1)

To calculate heart rate from a PPG signal, the time interval between successive peaks is measured. The following formula can be used in conjunction with the *findpeaks* function:

**Objectives**

**You will:**

* Construct and test either a transmissive or reflective photoplethysmography sensor circuit (extra points for both!).
* Collect and analyze PPG signals from both methods.

**Materials**

* Arduino
* Breadboard
* Green LED
* Wires
* Resistors
* Laptop or computer with MATLAB software
* Photoresistor

**Specific Tasks**

**1. Circuit Construction**

* **Transmissive Method:** Set up a circuit on a breadboard where the green LED and photoresistor are placed across the finger, so the LED illuminates one side of the finger and the photoresistor detects transmitted light on the opposite side. Photoresistors require a resistor in series of about 1k Ohms leading to ground.
* **Reflective Method**: Set up an alternative circuit where both the green LED and photoresistor are placed side-by-side on the same side of the finger, detecting the light reflected from the tissue. Photoresistors require a resistor in series of about 1k Ohms leading to ground.

**2. Data Acquisition**

* Develop MATLAB code to interface with Arduino for both transmissive and reflective methods, capturing analog signals from the photoresistor.
* Record intensity variations due to blood flow in your fingertip for each method separately, each for a duration of at least 30 seconds.
* Save each set of recorded signals separately in MATLAB-compatible (.mat) files.

**3. Signal Processing and Analysis**

* Preprocess raw PPG data from both methods to remove artifacts and noise using MATLAB filtering techniques.
* Implement peak detection algorithms in MATLAB to identify pulse peaks accurately.
* Calculate and report the heart rate in beats per minute (BPM).

**4. Results Visualization**

* Generate and clearly label MATLAB plots to illustrate:
  + Raw and filtered PPG signals.

**5. Method Comparison (BONUS TASK – OPTIONAL)**

* Compare signal quality, including clarity of peaks, noise levels, and overall consistency, between the transmissive and reflective methods.

**Submission Requirements**

* Submit a comprehensive report with clearly defined sections: Introduction, Materials and Methods, Results, Discussion, and Conclusions. Include pictures of the circuits.
* Provide your MATLAB scripts (.m files) and collected datasets (.mat files).
* Include a video showcasing the data collection process.

1. Saquib, Nazmus, et al. *Measurement of Heart Rate Using Photoplethysmgraphy*, cs-people.bu.edu/papon/pdfs/2015a\_NS\_MTIP\_IA.pdf. [↑](#footnote-ref-1)