AYDIN ADNAN MENDERES UNIVERSITY

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BIOMEDICAL SIGNAL ANALYSIS AND MACHINE LEARNING

MIDTERM HOMEWORK : Signal Key Point Detection

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PPG Signal Key Point Detection on Sliding Window

What is Photoplethysmography (PPG)?

Photoplethysmography (PPG) is an optical method used to hit upon volumetric changes in blood withinside the peripheral circulation. PPG is commonly received the use of a pulse oximeter, which illuminates the pores and skin and measures changes in light absorption. The heart pumps blood in the course of the frame with every cycle. Although this blood pressure is fairly damped whilst it reaches the skin, it's far enough to inflate the arteries and arterioles withinside the subcutaneous tissues. At this point, extent modifications may be measured with the PPG technique. Since blood glide to the pores and skin may be modulated through many physiological systems, PPG technique is likewise used to reveal respiration, hypovolemia and different circulatory conditions.

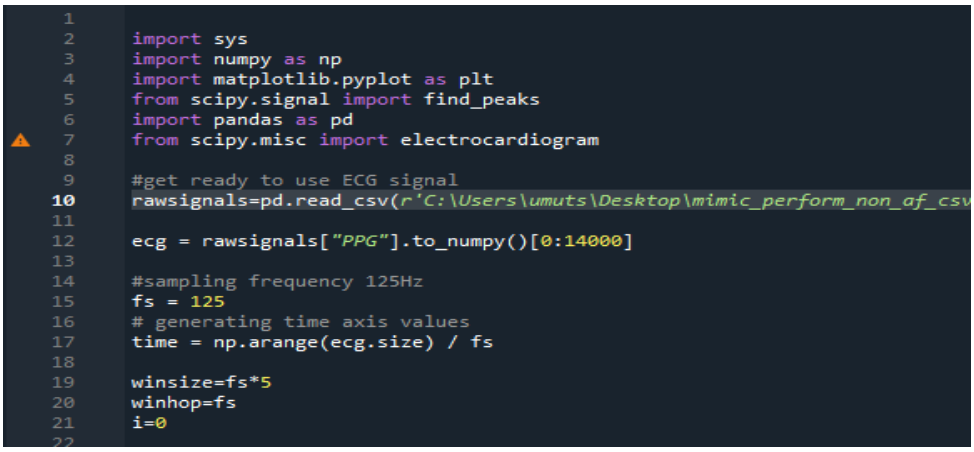
PPG Signal Dataset:

This dataset contains ECG and PPG recordings of 20-minute duration which were acquired during non atrial fibrillation (non-AF).

What We Did Using the PPG Signal Dataset?

We created a script that detects, marks and writes key points in a keyboard-controlled sliding window. For PPG signals, we set the sampling frequency to 125Hz. We used the sliding window size as 5s and the jump value as 1s. We developed software that can mark Pulse Wave Begin, Pulse Wave Systolic Peak, Dicrotic Notch, Pulse Wave Diastolic Peak and Pulse Wave End points. We found the mean values of Heart Rate (HR), Pulse Wave Duration (PWD), Diastolic Phase (DP) and Pulse Wave Amplitude (PWA).

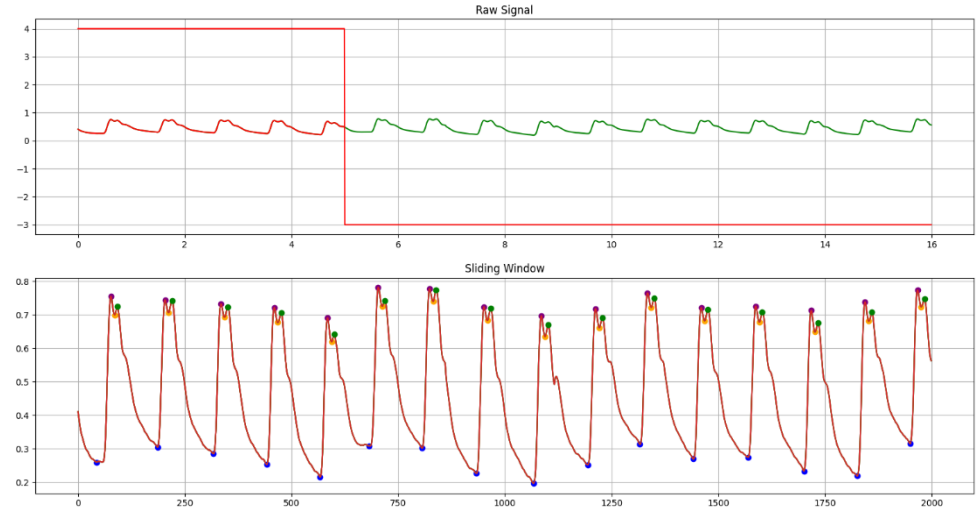
The following image indicates way to set the sampling frequency to 125Hz, sliding window size to 5s and skip value to 1s for PPG signals.



```
1
2   import sys
3   import numpy as np
4   import matplotlib.pyplot as plt
5   from scipy.signal import find_peaks
6   import pandas as pd
7   from scipy.misc import electrocardiogram
8
9   #get ready to use ECG signal
10  rawsignals=pd.read_csv(r'C:\Users\umuts\Desktop\mimic_perform_non_af_csv
11
12  ecg = rawsignals["PPG"].to_numpy()[0:14000]
13
14  #sampling frequency 125Hz
15  fs = 125
16  # generating time axis values
17  time = np.arange(ecg.size) / fs
18
19  winsize=fs*5
20  winhop=fs
21  i=0
22
```

The graphic beneath indicates the Pulse Wave Begin, Pulse Wave Systolic Peak, Dicrotic Notch, Pulse Wave Diastolic Peak and Pulse Wave End points of the PPG signal dataset marked withinside the 0-2000 and 0-14000 range.

Şekil 1: PPG signals withinside the variety of 0-14000 values.



Şekil 2: PPG signals withinside the variety of 0-2000 values.

The image below indicates the mean values of Heart Rate (HR), Pulse Wave Duration (PWD), Diastolic Phase (DP) and Pulse Wave Amplitude (PWA).

```
In [5]: runfile('C:/Users/umuts/Desktop/ppg_son.py', wdir='C:/Users/umuts/Desktop')
Heart Rate: 57.3596904809588
PWD: 125.33636363636364
DP: 106.21818181818182
PWA: 0.4626677330489651
```

Heart Rate (HR): Heart rate (or pulse rate) is the frequency of the heartbeat measured by the number of contractions (beats) of the heart per minute (bpm).

Diastolic Phase (DP): Diastole is defined as the period between aortic valve closure and mitral valve closure (diastole is considered to start with the onset of relaxation of ventricular muscle contraction just proceeding the closure of the aortic valve), which consists of four phases: isovolumic relaxation, rapid filling, diastasis, and atrial systolic phases.

Pulse Wave Amplitude (PWA): Pulse wave amplitude (PWA) is a signal obtained from finger photoplethysmography which is directly and positively correlated to finger blood flow.

Function to find the mean value of Heart Rate (HR)

```
22
23  def heartRate(firstPeak):
24      elemanSayisi=len(firstPeak)
25      i=0
26      sum=0
27      while i<elemanSayisi-1:
28          sum=sum+((125/(firstPeak[i+1]-firstPeak[i]))*60)
29          i=i+1
30      print("Heart Rate:",str(sum/elemanSayisi-1))
31
```

Function to find the mean value of Pulse Wave Duration (PWD)

```
58  def pwd(peaks2):
59      elemanSayisi=len(peaks2)
60      i=0
61      sum=0
62      while i<elemanSayisi-1:
63          sum=sum+(peaks2[i+1]-peaks2[i])
64          i=i+1
65      print("PWD:",str(sum/elemanSayisi-1))
```

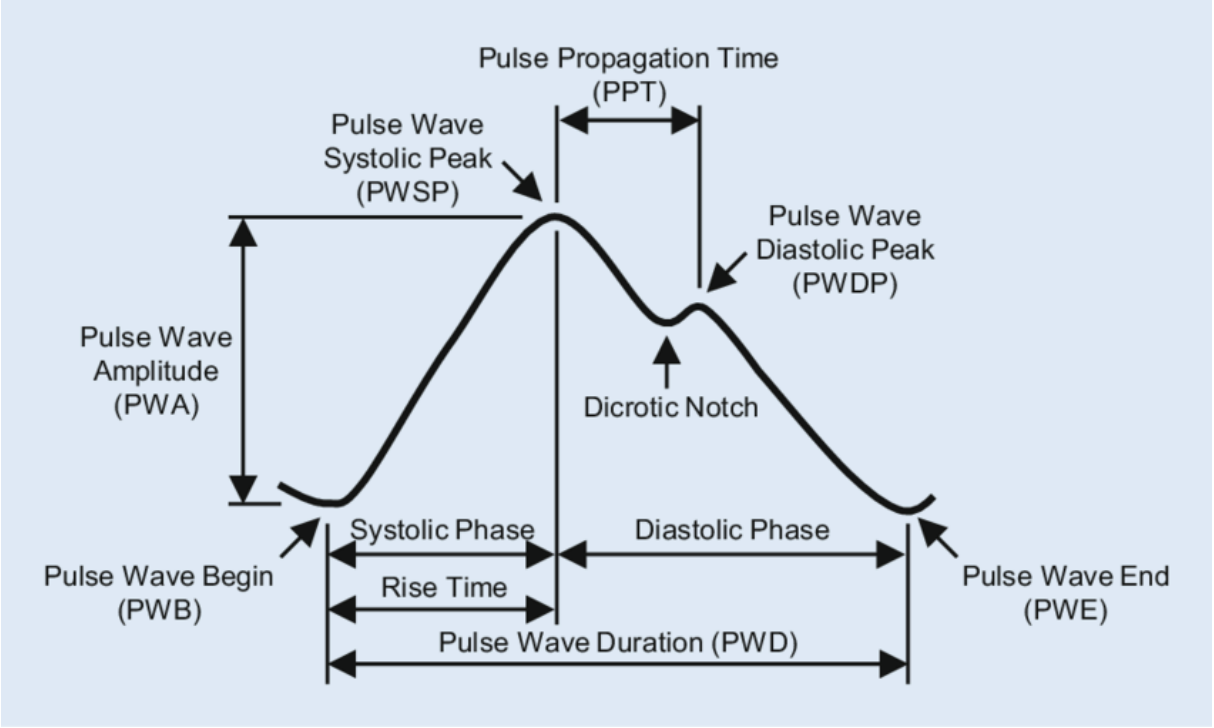
Function to find the mean value of Diastolic Phase (DP)

```
42
43  def dp(firstPeak,peaks2):
44      control=len(ecg[firstPeak])
45      i=0
46      toplam=0
47      count=0
48      while i<control-1:
49          if (peaks2[i+1]-firstPeak[i]) <0:
50              i=i+1
51              count=count+1
52          else:
53              toplam=toplam+(peaks2[i+1]-firstPeak[i])
54              i=i+1
55      print("DP:", str(toplam/control-1))
56
```

Function to find the mean value of Pulse Wave Amplitude (PWA).

```
32
33  def pwa(firstPeak,peaks2):
34      i=0
35      toplam=0
36      control=len(ecg[firstPeak])
37      while i<control:
38          toplam=toplam+ecg[firstPeak][i]-ecg[peaks2][i]
39          i=i+1
40      print("PWA:",str(toplam/control))
41
```

The image below indicates 8 Pulse waveform of photoplethysmogram (PPG)



References:

https://www.researchgate.net/figure/Pulse-waveform-of-photoplethysmogram-PPG-AC-part-with-pulse-wave-characteristics-4-10_fig1_317747949

Motion Compensated Pulse Rate Estimation by Wearable Device Data

https://github.com/sahikabetul/Motion-Compensated-Pulse-Rate-Estimation-by-Wearable-Device-Data

Photoplethysmographic-Signals

https://github.com/tariqul-islam/Photoplethysmographic-Signals

Cardiological data processing

https://github.com/Nico-Curti/cardio

Heartrate_Analysis

https://github.com/smritisridhar41/Heartrate_Analysis

Photoplethysmogram-based Real-Time Cognitive Load Assessment Using Multi-Feature Fusion

Model Resources

https://github.com/qiriro/PPG

NAS-PPG

https://github.com/coloriz/NAS-PPG

PPG-Heart-Rate-Classifier

https://github.com/galkn/PPG-Heart-Rate-Classifier