Effect of Filtering on Pulse Wave Transit Time Measured by Photoplethysmography

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Background: The waveform of a photoplethysmography (PPG) signal depends on the measurement site and individual physiological conditions. Pulse transition time (PTT) is an important physiological parameter for blood pressure estimation. In many wearable applications, the original PPG signals are filtered before feature extraction. Filtering can change PPG signal waveform and the timing of PPG feature points. We aim to quantitatively investigate the filtering-induced PTT changes at different measure sites in healthy subjects of different ages.

Methods: The ECG, and fingertip and earlobe PPG signals were recorded simultaneously at a sample rate of 2500 Hz for 120 s from 58 young (age<=50) and 40 old (age>50) healthy adults. The PPG signals were preprocessed (band-pass, pass and stop bands: >0.5 Hz and <0.2 Hz for high-pass filter, <20 Hz and >30 Hz for low-pass filter) and then filtered (low-pass, pass and stop bands: <3 Hz and >5 Hz). We used the R-peak of the ECG and the end-of-diastolic valley to calculate the PTT with different conditions, as shown in Fig1. The relative PTT difference was calculated as:

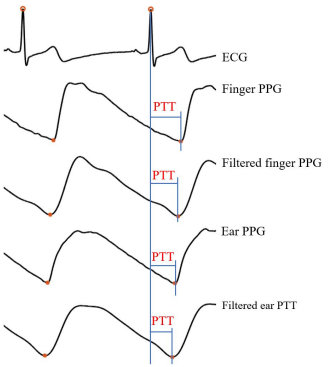

Figure 1: Calculation of pulse transit time (PTT) using synchronously recorded ECG and PPG signals at different body sites.

$$RD_{PTT}=(PTT_{filtered}-PTT_{preprocessed})/PTT_{preprocessed}$$

Results: IIR filtering caused the shorting of PTT in both age groups (i.e., young and old) and measurement sites (i.e., fingertip and earlobe). The results show significant effect of age and measurement site on filtering-induced PTT difference and its relative difference ($p<0.05$ for all). The young group has a significantly larger (lower negative values) filtering-induced PTT difference than the old group in all measurement sites.

Conclusion: The filtering-induced PTT difference was significantly different between PPG signals at fingertip and earlobe, and between different age groups. The physiological factor including measurement site and age should be considered in PTT-based blood pressure estimation using wearable sensors.