Study on the Generalization Ability of Accelerometer Threshold-based Methods for Noise Detection in PPG signals

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Background and Aim. Continuous heart rate monitoring through wearable devices incorporating photoplethysmogram (PPG) sensors commonly provides very noisy signals, especially during daily activities and physical exercise. One common approach to deal with this limitation is the use of additional sensors, such as an accelerometer, to discard periods where movement exceeds a certain threshold. Precisely, motion artifacts are one of the main noise sources sharing frequency band with the PPG signal and cannot be removed by filtering without discarding the desired signal as well. However, little research can be found in the literature about how extrapolable the accelerometer threshold-based methods are to successfully work with different databases. Hence, the aim of the present work is to quantitatively assess the performance of some of these methods on several datasets acquired with different PPG sensors.

Methodology. All recordings from the public datasets PPG DaLiA and WESAD were segmented into 5 second-length intervals. They were then labeled as clean or noisy on the difference in the inter-beat interval between the available synchronous ECG and PPG signals, as this labeling method has been deemed more objective than manual annotation. Next, diverse acceleration thresholds in the range between 0 and 1.5g were applied to two acceleration metrics, i.e., the acceleration vector module for the raw signal of each axis and the filtered signal of each axis. Finally, the classification obtained by each threshold was compared with the reference labels in terms of accuracy.

Results. Values of maximum accuracy larger than 75% were obtained on both databases, but for accelerometer thresholds notably different. Precisely, when an error lower than 8 bpm between the heart rate derived from the ECG and PPG signals was considered to label clean excerpts, the accelerometer threshold reporting the higest accuracy was 0.05g for PPG DaLiA and 0.26g for WESAD. Similarly, for a error of 3 bpm, maximum accuracy was obtained for the thresholds of 0.02g and 0.24g, respectively.

Significance. These results suggest that accelerometer threshold-based methods for PPG noise detection can be moderately effective for a single dataset, but fail to generalize to other databases acquired with different PPG sensors. This involves a large limitation for many real-world medical applications.