Beat-to-beat Intervals of Speckle & Intensity-based Optical Plethysmograms compared to Electrocardiogram

Jorge Herranz Olazábal [1,2], Fokko Wieringa [3,4], Evelien Hermeling [3], Chris Van Hoof [1,2]

[1] Imec, Leuven, Belgium
[2] KUL, Leuven, Belgium
[3] Imec NL, Eindhoven, The Netherlands
[4] University Medical Center Utrecht, Utrecht, The Netherlands

Objectives. We compared beat-to-beat (b-2-b) intervals derived from two types of optical plethysmography, using electrocardiography (ECG) as a common reference (9 human volunteers, 3235 heart-cycles in total, all signals recorded simultaneously). The first optical signal was commonly used transmission *contact*-mode photoplethysmography (PPG) from a clinical finger probe. The second optical signal was obtained by laser speckle contrast analysis of video sequences, also known as *remote* speckleplethysmography (rSPG).
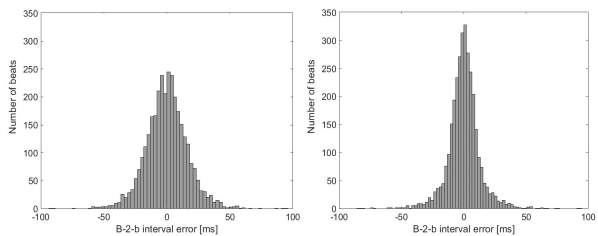
Methods. PPG: Recorded from the analog output of a Finapres Nova with a Covidien finger probe (75 Hz sampling) using a Biopac MP160 (12.5 kHz sampling). rSPG: We illuminated the index finger with a diode laser (639 nm, 10 mW, 25 cm distance), captured video streams with a camera (Basler acA2000-340km, 25 cm distance, 100 fps) and evaluated spatial variations across all consecutively captured speckle patterns. The resulting rSPG time domain signal was resampled to 12.5 kHz to match the Biopac PPG sampling.

Results. For both rSPG and PPG, we calculated all b-2-b intervals between the onsets of the upstrokes (foot-to-foot) and compared them with the corresponding ECG R-R intervals. Compared to reference ECG, b-2-b interval deviation distributions of rSPG vs contact PPG showed: Mean absolute deviation 10.4 vs 14.2 ms; standard deviation 25.2 vs 30.1 ms; two-sample F-test confirmed that the observed difference in variance was significant ($p < 0.001$, 99% confidence).

B-2-b time deviations of PPG (left - finger probe) and rSPG (right - camera-derived) versus ECG reference.

Conclusion. This study demonstrates that *contactless* camera-derived rSPG can obtain b-2-b intervals with an accuracy at least as good as routine clinical *contact*-mode transmissive finger clip PPG. This might enable innovative applications.