Optimising Smartphone Camera Parameters for Reliable Photoplethysmography

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Photoplethysmography (PPG) using a smartphone camera provides a low-cost and widely accessible method for measuring pulse waveforms from the fingertip. However, the impact of adjustable camera parameters, such as ISO, exposure time (E), focus (F), and white balance (WB), on PPG signal quality remains insufficiently understood. In this study, we systematically investigate how smartphone camera configurations influence pulse waveform quality.

Data were collected using an iPhone 13 mini and a dedicated version of the OpenPPG mobile application that enables manual adjustment of camera parameters. Ten camera presets were defined using different combinations of ISO, E, F, and WB. For each preset, signals were simultaneously extracted using five pixel selection strategies: 5-point (five regions of four pixels), grid (nine regions of four pixels), random (24 randomly distributed pixels per frame), central (four central pixels), and threshold-based (top 5% brightest pixels per frame), yielding 50 configurations per participant. One-minute PPG recordings were acquired from 44 healthy participants (18 females; 27.4 ± 5.1 years; Fitzpatrick skin types I–V; 1795 included recordings), alongside single-lead ECG as a reference. Performance was assessed by comparing the mean heart rate (HR) derived from PPG and ECG, and by estimating the signal-to-noise ratio (SNR). The grid-based method yielded the lowest mean HR difference (ΔHR = 3.94 BPM) and highest SNR (mean SNR = 0.89; max = 0.91 ± 0.04 for presets 1 and 6), whereas the random method failed to produce detectable pulse waveforms. Across presets, the lowest HR differences were observed at the longest E (E = 0.033 s; presets 4, 7, 10; 2.64–2.80 BPM) and the highest ISO=400 (presets 6, 7; 2.78–3.00 BPM).

These findings identify camera configurations that may optimise smartphone-based PPG. Future work will address heart rate variability and the stability of derived PPG-based features to support medical-grade applications.

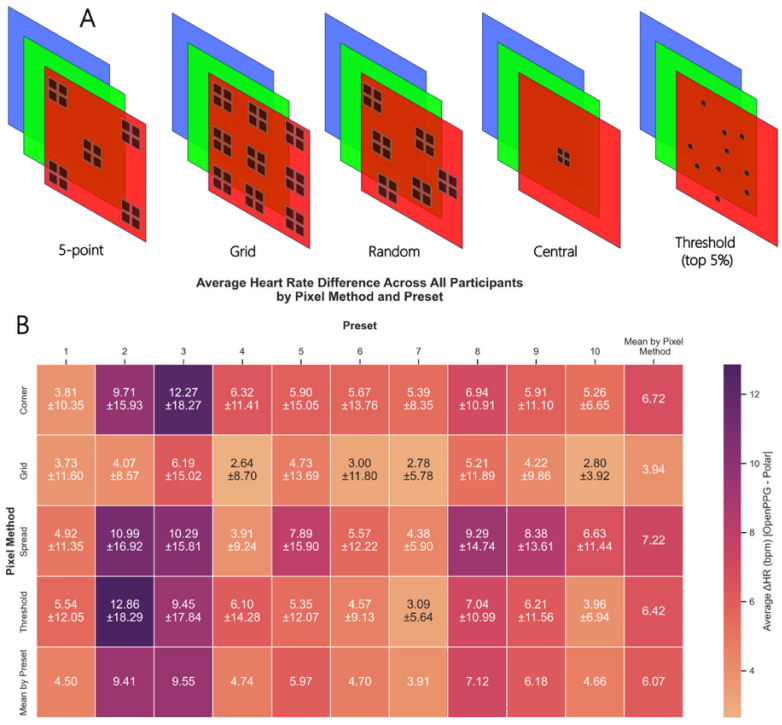

Figure. A) 5 pixel selection strategies. B) Average HR differences by pixel selection strategies and presets.