Exploring Relation of Photoplethysmography (PPG) and Heart Rate Variability (HRV)

Presented by

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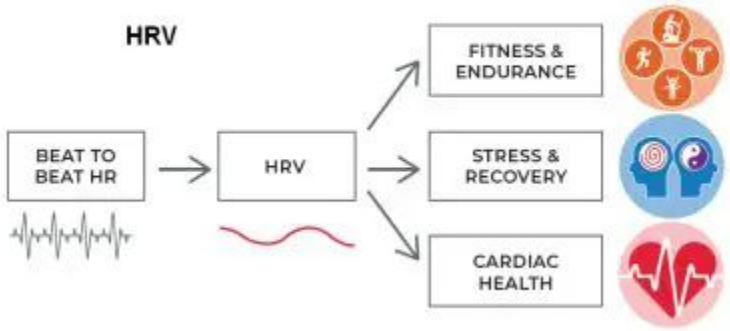
Recap

PPG: Optical technique measuring blood volume changes for heart rate.

HRV: Time interval variation between heartbeats, indicating autonomic balance.

Applications: Wearables (WHOOP, Oura) use these metrics for stress, sleep, and recovery tracking.



How to Derive HRV from PPG

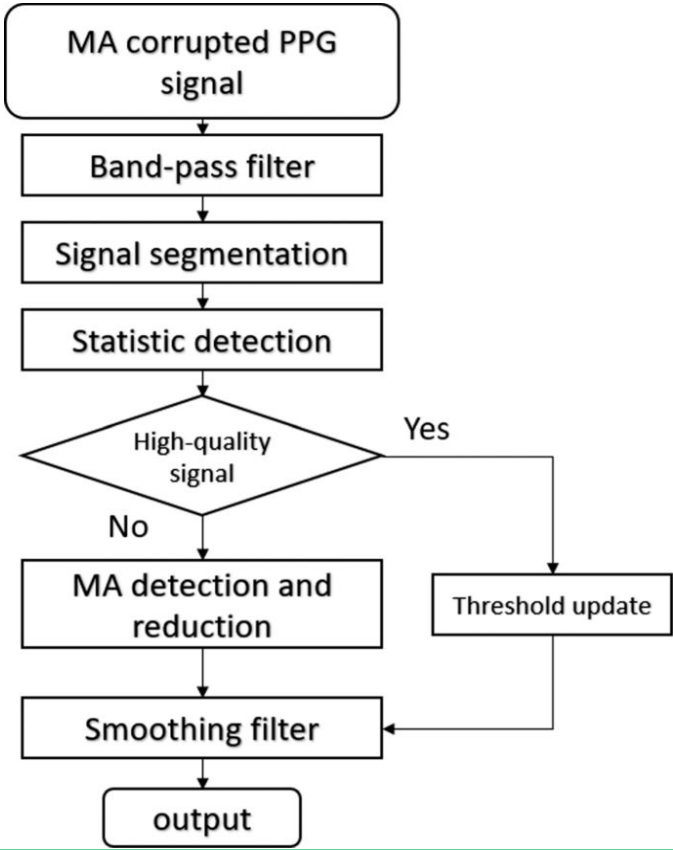
Capture PPG signal from wearable sensors.

Remove noise (motion artifacts, environmental interference).

Detect heartbeats by identifying peaks in the signal.

Calculate RR intervals (time between consecutive peaks).

Use RR intervals to determine HRV.



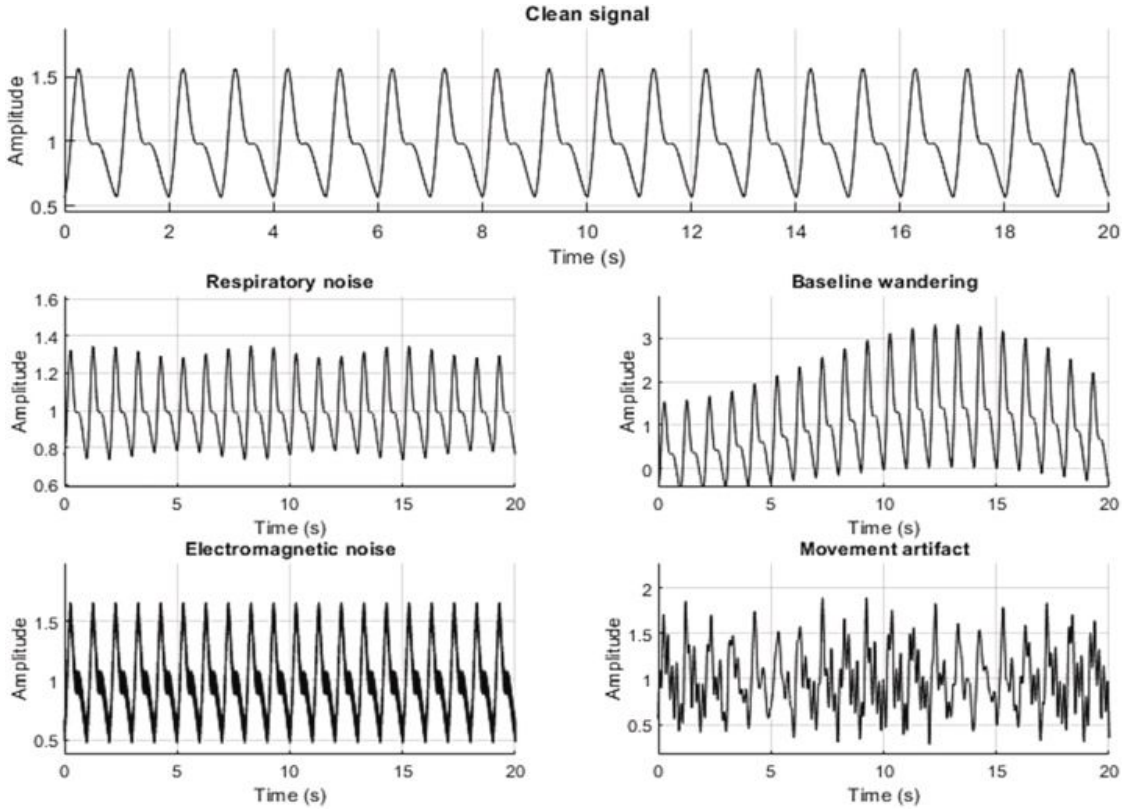
Common Noises in PPG

Movement Artifacts

Electromagnetic Noise

Baseline Wandering

Respiratory Noise

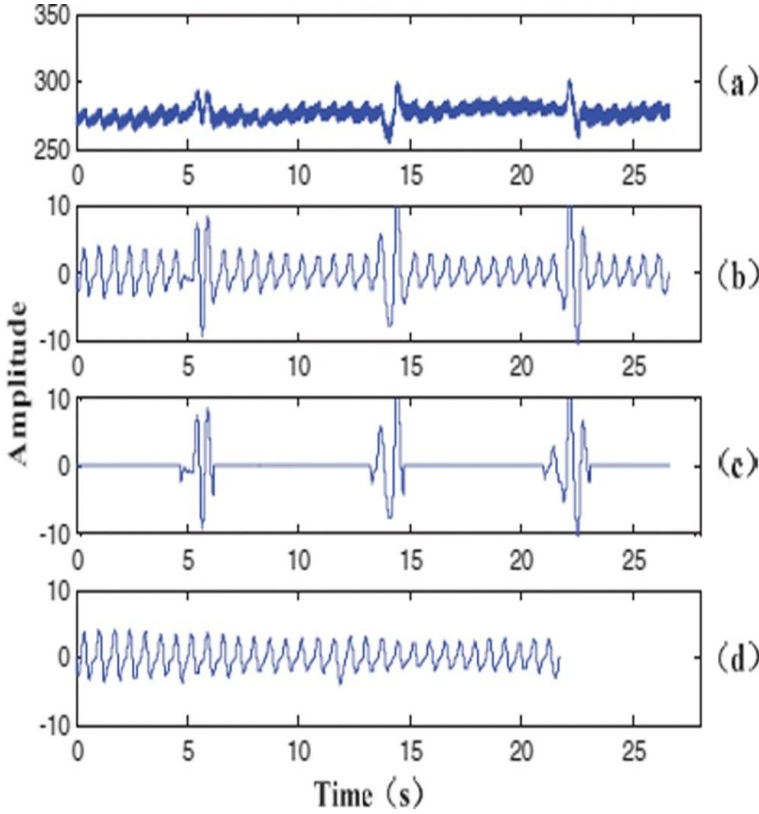


Example of Filtering Mechanism

Signal Preprocessing: Low-pass filters to remove high-frequency noise.

Artifact Removal: Adaptive filtering to account for motion artifacts.

Peak Detection: Smoothing techniques to ensure accurate identification of heartbeats.



a Original PPG signal, b PPG after pre-processing, c detected movement, d cut-out algorithm applied

Reliability of PPG-Derived HRV

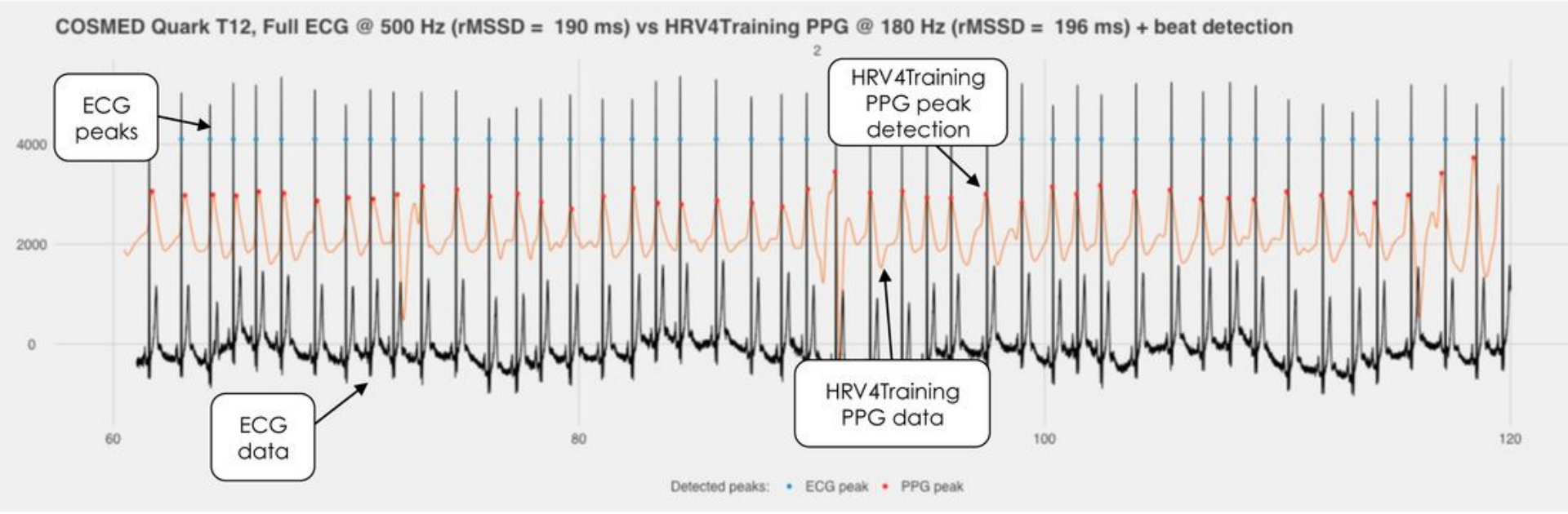
Compared to ECG: Reliable during rest, less accurate during motion.

Wearables' Improvements: WHOOP and Oura are enhancing accuracy through better algorithms.

Current Limitations: Motion and environmental factors still affect PPG-derived HRV accuracy.

Research Supporting PPG-Derived HRV - 1

Here’s a brief comparison of PPG derived peaks vs ECG by HRV4Training



Research Supporting PPG-Derived HRV - 2

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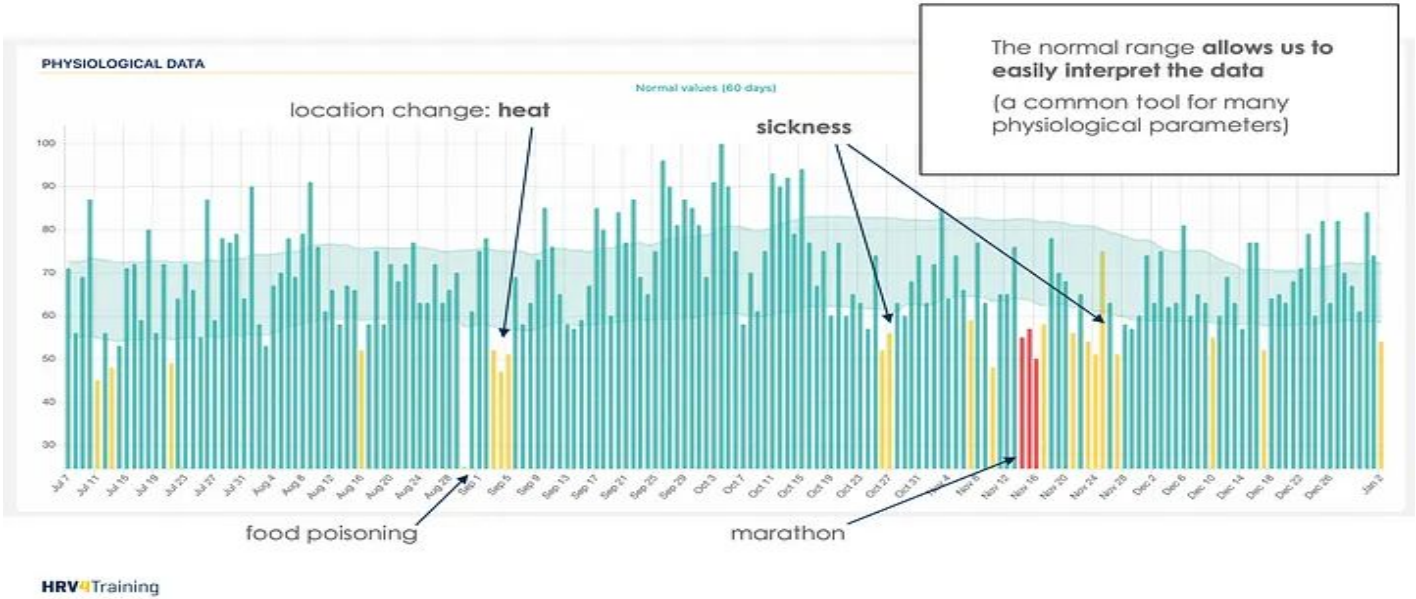

References

HRV4Training - publications, medium article for HRV

Signal Filter -

Detection and Removal of Motion Artifacts in PPG Signals | Mobile Networks and Applications

Signal Noise -

Effects of noise and filtering strategies on the extraction of pulse rate variability from photoplethysmograms - ScienceDirect