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Heuristic algorithm for photoplethysmographic heart rate tracking during maximal exercise test

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Abstract— Photoplethysmography (PPG) is a non-invasive optical technique that can be used to quantify the arterial blood pulse rate. Signal corruption by motion artifacts limits the practical accuracy and applicability of instruments for monitoring pulse rate during intense physical exercise. This study develops and validates an algorithm, which is based on linear filtering and frequency-domain and heuristic analyses, for extracting the heart rate from a PPG signal in the presence of severe motion artifacts. The basis of the hearth beat frequency selection is the observed high harmonic content of movement artifact signals with respect to the PPG-derived heartbeat. The algorithm, implemented in an experimental PPG measurement device, is developed by analyzing a set of PPG data recorded from a group of athletes exercising on a treadmill. An extensive set of tests is carried out during maximal exercise tests on a treadmill to validate the proposed algorithm by comparison with a reference electrocardiography measurement system. The Bland-Altman method is used to compare and evaluate PPG signals. The accuracy of the heartbeat measurement is better than ± 6.5 beats per minute (bpm) (= 4.2 %) even under maximal exercise conditions.

Index Terms— Biomedical signal processing, photoplethysmography (PPG), motion artifact, heart rate

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