GPU-Based Segmented-Beat Modulation Method for Denoising Athlete Electrocardiograms During Training

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Sport-related sudden cardiac death (SRSCD), defined as "death occurring during sport or within one hour of cessation of training", is the leading cause of death in athletes. SRSCD occurs in the presence of underlying cardiovascular diseases, some of which may be identified by processing electrocardiographic recordings acquired during training (TECGs). Popular wearable monitoring sensors of cardiac activity are typically used for training optimization. Still, they can also provide useful information for SRSCD risk assessment. However, for a timely prediction of critical events, TECGs from wearable sensors need to be efficiently and accurately processed during or immediately after training. This is a challenging task since TECGs are typically highly corrupted by noise and interferences, which may jeopardize their interpretation and identification of abnormal morphologies. The present study aims to evaluate the ability of the segmented-beat modulation method (SBMM) to denoise TECGs, and to improve SBMM implementation by GPU acceleration to make it compatible with modern hardware. To this aim, 19 4-to-6 min TECGs (sampling frequency: 256 Hz), acquired from 8 subjects while performing 4 different exercise tasks (walk, run, low-resistance bike and high-resistance bike), were analyzed. All data were taken from the "Wrists PPG During Exercise" database by Physionet. Signal-quality improvement was evaluated by computing the signal-to-noise ratio (SNR_{dB}) for power of TECGs before and after GPU-SBMM application. Speed-up factor due to GPU acceleration was also evaluated. Results indicate that GPU-SBMM application yielded a significant increase of SNR_{dB} (from 1±5 dB to 19±5 dB; $P<10^{-10}$). Results stratified by exercise tasks are reported in the Table. Additionally, a considerable speed up in the algorithm runtime (3.56x on average on an NVIDIA GeForce GPU) was achieved. In conclusion, GPU-SBMM is an efficient and accurate algorithm for TECG processing and may help fighting SRSCD.

Comparative evaluation of SNR_{dB} by activity

Exercise tasks	# TECGs	Before SNR_{dB}	After SNR_{dB}
Walk	6	-2±3	18±5*
Run	5	1±7	20±7*
Low-resistance bike	5	3±5	3±5*
High-resistance bike	3	3±6	20±4

*$P<0.05$ when comparing after vs before SNR_{dB}