

Integrating the exercise and environmental data into a digital ECG structure by watermarking technique

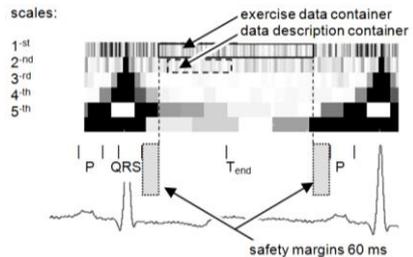
Piotr Augustyniak

AGH University of Science and Technology
Krakow, Poland

Exercise Test is worldwide recognized as valuable tool for investigating ST segment-based ischemia markers. Due to load-related risk, the test is reserved for office use, what causes inconvenience, limits patient participation rate and precludes screening for early ischemia stages. Transferring the diagnosis to patients' premises and using everyday activities as stimulus is an interesting alternative, but needs reliable recording of physical load data.

This paper presents a method for integrating the exercise and environmental data into a digital ECG structure by watermarking technique. The method analyses the time-scale ECG representation, detects the bandgap, where the bandwidth of actual cardiac content is lower than the throughput of digital series, detects the noise and replaces it by exercise-related data. Unless in irregular signals, the capacity of data container can accommodate an accompanying accelerometer and blood pressure signal without deteriorating the ECG content. This makes possible to perform ECG exercise test in home conditions without additional transmission channels or data structures.

The method was tested with CSE database according to EN60601-2-25:2015 and proved the watermarked ECG to maintain the wave borders accuracy within tolerance limits. Consequently, restoration of original ECG record is not necessary. The method was also tested with anonymized stress-test records, which were watermarked with accelerometer data and re-interpreted to compare results with original diagnoses.



Watermarking the exercise data in time-scale ECG representation.

Comparing results from 17 stress ECGs

S-T Parameter	Difference	
	mean	std
elevation/depression [μ V]	± 15.7	41.0
threshold mismatch cases	2	
slope coefficient	± 0.157	0.203
slope sign mismatch cases	1	

Watermarking of the ECG may also be helpful for integrating environmental data making interpretation context for homemade exercise test and we are looking forward for a real-time hardware implementation of the encoder.