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

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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 partici-
pation 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 phys-
ical load data.

This paper presents a method for integrating the exercise and envi-
rornmental data into a digital ECG structure by watermarking tech-
nique. 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 accel-
erometer and blood pressure signal without deteriorating the ECG content.
This makes possible to perform ECG exercise test in home conditions with-
out additional transmission channels or data structures.

The method was tested with CSE database accordingly 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 of the ECG may also be helpful for inte-
grating environmental data making interpretation context
for homemade exercise test and we are looking forward for a real-time hardware
implementation of the encoder.