Automated Identification of Paced Beats in Holter ECG

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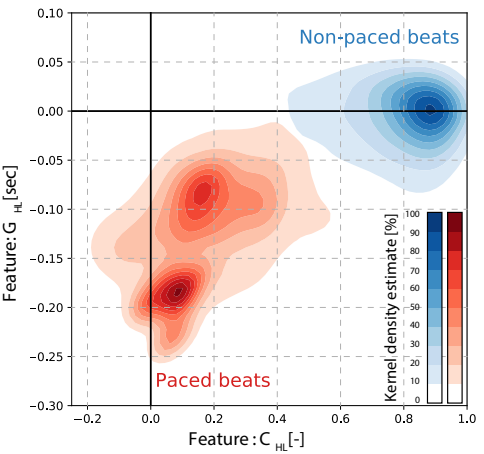
Background: Beat type quantification is one of the required outputs of Holter monitoring reports. This quantification also involves the identification of paced beats. However, lower sampling frequencies used in long-term Holter recordings causes suppression of pacing stimuli, making them hard to identify. Here, we present a method distinguishing between paced and non-paced beats.

Method: One-hour recordings (120 patients, single lead, 250 Hz) were recorded using the ECG Holter device (FAROS 180) during usual daily activities. A total of 44,918 QRS complexes were detected and marked as paced (19,004) or non-paced (25,914) in the SignalPlant software.

At the beginning of the feature extraction process, the ECG signal close to a center of each QRS complex (window radius RR/2, max. 0.5 sec) was transformed into a high-frequency amplitude envelope (Env_H, 70-100 Hz) and low-frequency amplitude envelope (Env_L, 0-22 Hz). Next, three features were extracted for each QRS complex. The first feature was computed as a correlation between Env_H and Env_L (C_{HL}); the second feature was a temporal difference of centers of gravity in Env_H and Env_L (G_{HL}). Finally, the third feature was a ratio of Env_H maximum to a maximal value of the QRS central region (+/- 0.025 sec, R_{HC}) in Env_H. Features were combined into a logistic regression model.

Results: Presented features were able to split paced and non-paced beats with an AUC value of 0.89, 0.90, and 0.94 for C_{HL}, G_{HL}, and R_{HC}, respectively. When data was split to training (60%) and testing set (out-of-patient), the resultant logistic regression model showed an F1-score of 0.93 using a testing set.

Conclusion: The presented method identifies paced heartbeats in lower sampling frequencies, even where it can hardly be visually observed in the raw signal. However, method performance with novel pacing approaches (as Hiss-bundle pacing) should be investigated.



Density plot by G_{HL} and C_{HL} features