QRS Complex Detection in Paced and Spontaneous Ultra-high-frequency ECG

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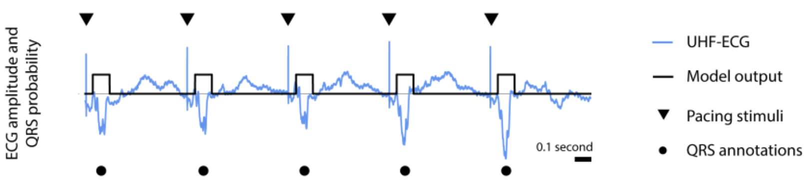
Background: Analysis of ultra-high frequency ECG (UHF-ECG, sampled at 5, 000 Hz) informs about dyssynchrony of ventricles activation. Nowadays, this information can be evaluated in real-time when optimizing a lead position during a pacemaker implantation procedure. However, our current solution for real-time QRS detection requires complex signal pre-processing to filter and remove pacemaker stimuli.

Aim: In this study, we present a deep learning method for QRS complex detection in UHF-ECG signals.

Method: We use a UNet convolutional neural network to process a 3-second window from V1, V3, and V6 lead of UHF-ECG. Each input lead was transformed to a z-score. The output of the network is a vector of QRS probabilities. Resultant QRS positions are based on QRS probability and distance criterion.



Results: The UNet model has been trained on 2,250 ECG signals acquired from 780 patients from the FNUSA-ICRC hospital (Brno, Czechia) and tested on 300 signals from 47 subjects from FNKV hospital (Prague, Czechia). We received an overall F1-score of 97.11 % on the test set with an F1-score of 96.3% and 97.25 % for spontaneous and stimulated QRSs, respectively. The proposed approach is superior to our previous solution, with an overall F1-score of 90.43 % on the test set. Test results showed an F1-score of 93.40 % and 89.91 % for spontaneous and stimulated QRSs, respectively.

Conclusion: Our results indicate that the proposed method should improve beat detection in real-time UHF-ECG analysis; the method does not require prior elimination of pacing artifact. Its higher sensitivity allows a reduction of measurement time if it is used during implantation.