Ultra-high Frequency Deep-learning Beat Detector Delivering QRS Onsets and Offsets

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Background: QRS duration is a common measure linked to conduction abnormalities in heart ventricles. We hypothesized that appropriately designed deep-learning QRS detector could also deliver this measure.

Aim: We propose a QRS detector, further able to locate QRS onset and offset. Therefore, QRS duration and QRS detection could be delivered in one inference step.

Method: A 3-second window from 12 leads of UHF ECG signal (5 kHz) is standardized and processed with the UNet neural network. The output is an array of probabilities, transformed into QRS onsets and offsets.

Results: The model had been trained on 2,250 ECG recordings from the FNUSA-ICRC hospital (Brno, Czechia) containing spontaneous and paced data and tested on 5 different datasets: private datasets from FNUSA and FNKV hospital (Prague, Czechia), and three public datasets (Cipa, Strict LBBB, LUDB). Results of the algorithm for QRS duration: Mean Absolute Error (MAE), Mean Error (ME), Standard Deviation (STD), and for QRS detection (F-score) are summarized in Table 1.

Table 1

Database	Rhythm	No of records	MAE [ms]	ME [ms]	STD [ms]	F-score [%]
FNUSA	Spont	450	8.64	6.22	11.15	99.42
	Paced	318	20.64	-13.41	12.17	97.59
FNKV	Spont	20	15.59	-7.76	7.79	98.53
	Paced	278	19.55	5.58	9.78	97.39
Cipa	Spont	5,749	9.40	-7.93	8.04	-
Strict LBBB	Spont	602	12.37	0.28	16.42	-
LUDB	Spont	200	12.78	0.04	11.46	-

Conclusion: Our results indicate high QRS detection performance on both spontaneous and paced UHF ECG data. We also showed that QRS detection and duration could be combined in one deep learning algorithm.