HFO detection and feature extraction algorithm based on image analysis of normalized amplitude envelopes

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Rational: Nowadays, several automated detectors of HFOs exist. However, identifying pathological HFOs, distinguishing them from physiological HFOs and linking their morphology to underlying pathophysiological processes still remains a challenging task. Contrary to other algorithms, which were developed to process big datasets, we present a tool for detailed HFO analysis based on precise feature calculation.

Methods: To evaluate the precision of basic feature calculation, artificial HFOs with known frequency (80~600 Hz), duration (3~6 cycles) and amplitude (0.1~0.3 std of signal amplitude) were introduced into an iEEG signal without pathologic activity and the difference between known and extracted features was calculated. In order to investigate the performance of the detector and its potential in clinic, post-processing steps were applied and ROC (see Figure) curve was calculated on the iEEG signal with gold standard marks using 100 ms sliding window.

Results: Mean differences of extracted feature values from known values were 5.5 +/- 18.6 Hz, 6.8 +/- 5.0 uV, 1.0 +/- 7.5 ms, for frequency, amplitude and duration, respectively. Performing ROC analysis the achieved sensitivity and specificity at the best operating point was 0.79 and 0.95, respectively, with the AUC = 0.88.

Discussion: The proposed detection algorithm can be used for studying HFOs through precise feature extraction. Such data can be clustered and evaluated with regard to epileptogenicty, behavioral states or anatomy. The results of such analyzes can be implemented into simpler but faster algorithms that would be suitable both for clinic and basic research. ROC analysis demonstrates feasibility for research and clinic.

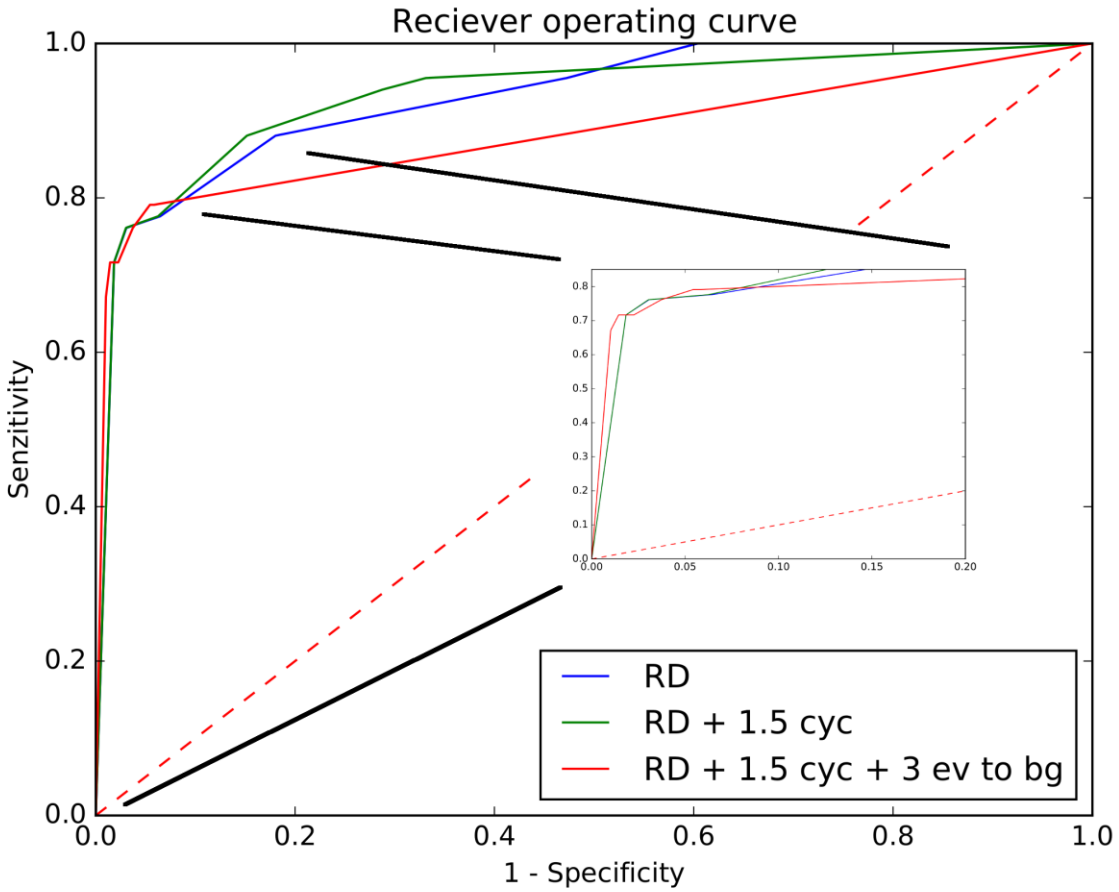

Figure: ROC curves for individual post-processing steps demonstrate increased performance when using a feature threshold cascade. Blue – Raw detection without using additional feature thresholds. Green – Raw detection with threshold for number of cycles. Red – Raw detection with thresholds for number of cycles and event to back ground ratio, which is defined as the mean amplitude ratio between the detection and the surrounding signal (+/- 250 ms).