Epilepsy seizure onset detection applying 1-NN classifier based on statistical parameters

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Abstract

Epilepsy is a disease caused by an excessive discharge of a group of neurons in the cerebral cortex. Extracting this information using EEG signals is an ongoing challenge in biomedical signal processing. In this paper, a new method is proposed for onset seizure detection in epileptic EEG signals based on parameters from the t-location-scale distribution coupled with the variance and the Pearson correlation coefficient. The 1-nearest neighbor classifier achieved a 91% sensitivity (True positive rate) and 95% specificity (True Negative Rate) with a delay of 4.5 seconds (on average) in the 45 signals analyzed, which suggests that the proposed methodology is potentially useful for seizure onset detection in epileptic EEG signals.

Methodology

Raw Data: EEG signals (23 channels) of 9 patients from the Children Hospital Boston database.

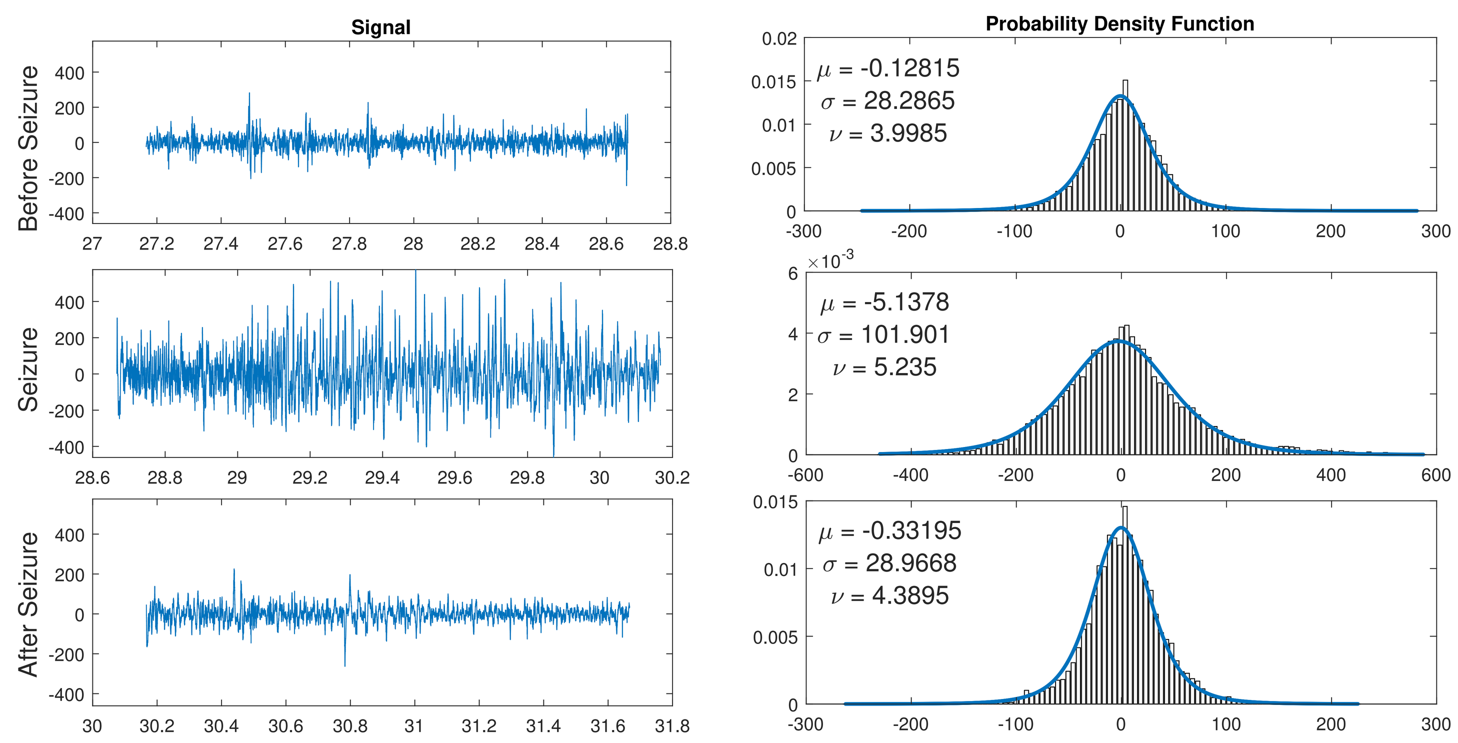
Selected Data: 5 channels from each patient were selected by an expert neurologist (FLENI) based on the the ability to see the seizure.

Epochs: Two rectangular sliding windows, each with a length of 3 seconds and an overlap of 50%.

Statistical parameters: Five features parameters: μ (location), σ (scale) and ν (shape) from t-location-scale distribution, σ^2 (variance) and ζ (Pearson correlation coefficient).

Classifier: The 1-nearest-neighbor (1NN) classifier using the feature predictor vector $\boldsymbol{\theta} = [\mu, \sigma, \nu, \sigma^2, \zeta]$ associated with each time segment and the response vector composed of seizure (1) or non-seizure (0).

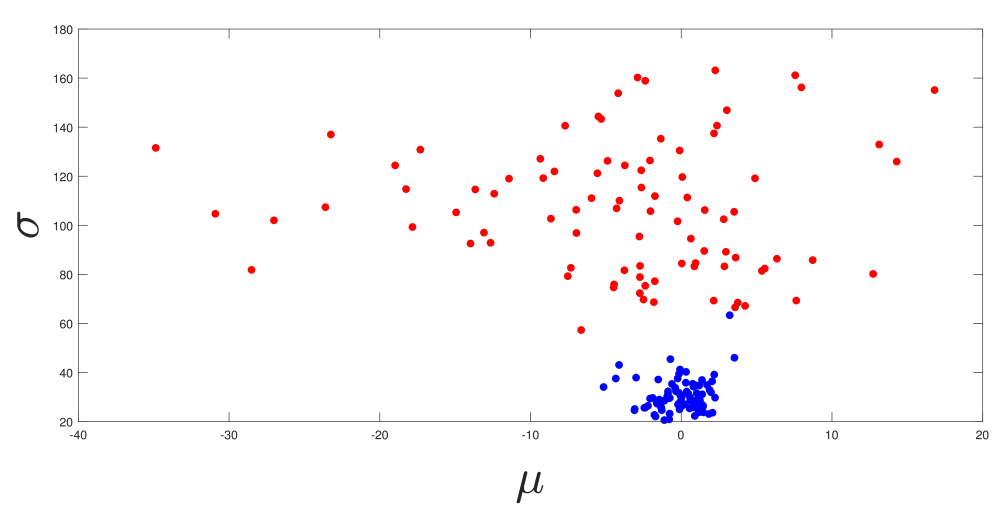
Probability Density Function

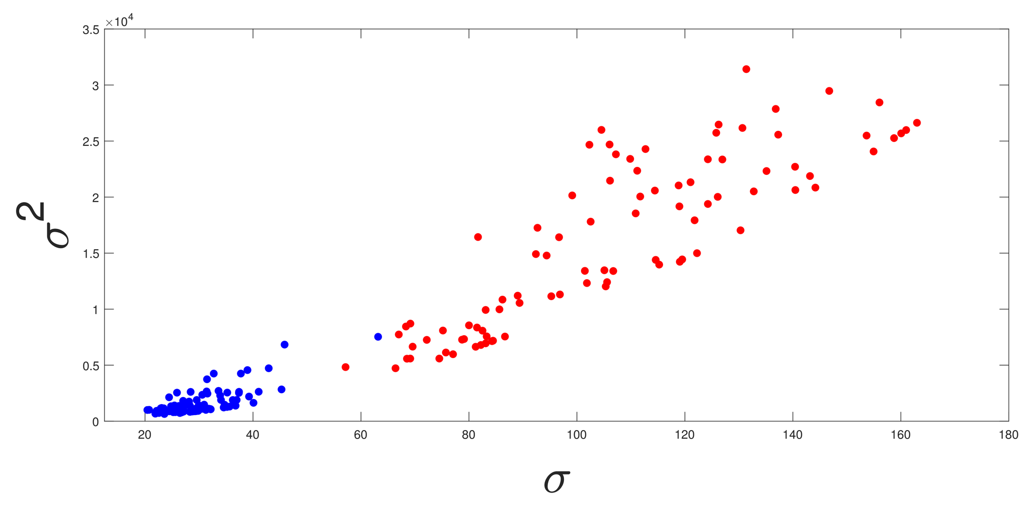


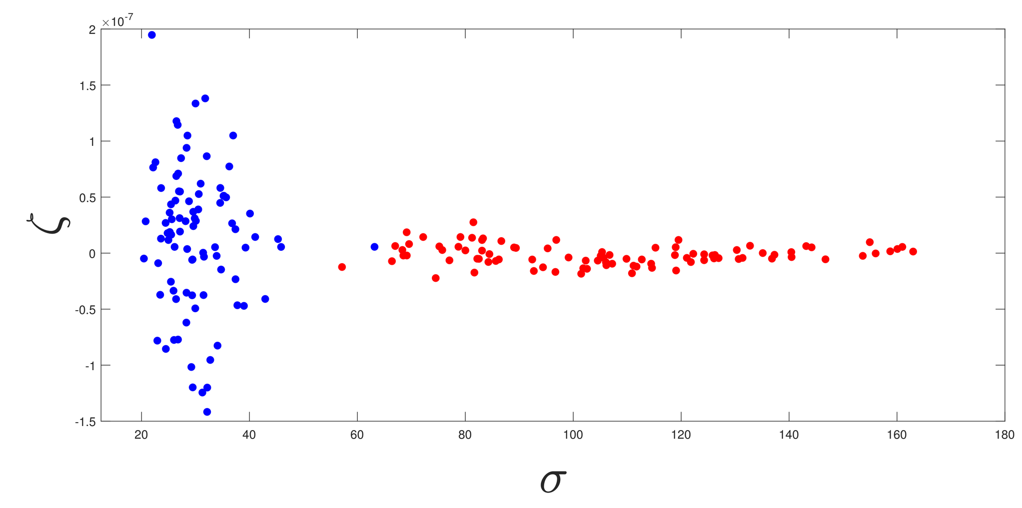
Note the high amplitude in the time domain during the seizure and the different values for the parameters μ, σ and ν.

Results and Discussion

To check the quality of our seizure onset detection classifier, the set was trained off-line with 40 signals with the 5 features of each vector $\boldsymbol{\theta}_1 = [\mu_1, \sigma_1, \nu_1, \sigma_1^2, \zeta_1]$ for seizure events and $\boldsymbol{\theta}_0 = [\mu_0, \sigma_0, \nu_0, \sigma_0^2, \zeta_0]$ for non-seizure events.
The classifier, using leave-one-out cross-validation, was applied to the training signals, where leave-one-out refers to a patients which has 5 channels. After each training, the remaining 5 bipolar signals (data from one patient), which where not included in the training but the seizure onset and offset where know, where predicted. This prediction was done 9 times in order to predict the 5 channels corresponding to each patient. A total of 15 signals were predicted.
The percentage of correct classifications was analyzed, in terms of sensitivity, specificity and accuracy. The values obtained are; 91% sensitivity (True positive rate), 95% specificity (True negative rate) and 95% accuracy for seizure on set detection in epilepsy signals. For each iteration, the prediction speed was 230000 obs/sec and training time was 4.4014 sec for 12480 observations.
In the following scatter plots, the blue corresponds to non seizure events and the red corresponds to seizure events. As it can be observed, a clear correlation exists between the value of the Pearson coefficient and sigma from the t-location scale distribution. For seizures, σ values are high and ζ tends to zero. As for non seizures, σ values are low and ζ can be found around a wider numerical range.







The research reflected in this paper using a feature vector $\boldsymbol{\theta} = [\mu, \sigma, \nu, \sigma^2, \zeta]$ in 45 epileptic signals for the classes seizure and non-seizure, suggests that the proposed methodology based on the t-location-scale distribution coupled with the variance and the Pearson correlation coefficient and the 1NN-based classifier, is potentially useful for seizure onset detection in epileptic EEG signals. The signals studied have a delay on average of 4.5 sec.

Acknowledgements

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