A new algorithm for automatic identification of spike-wave EEG signals in epileptic patient-specific

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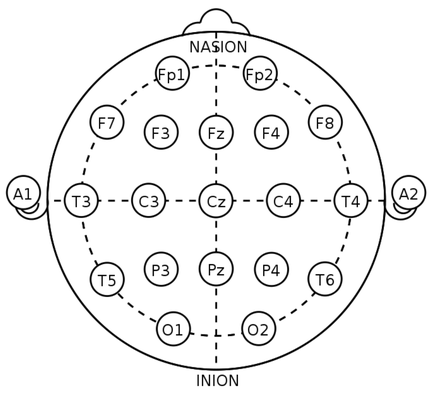
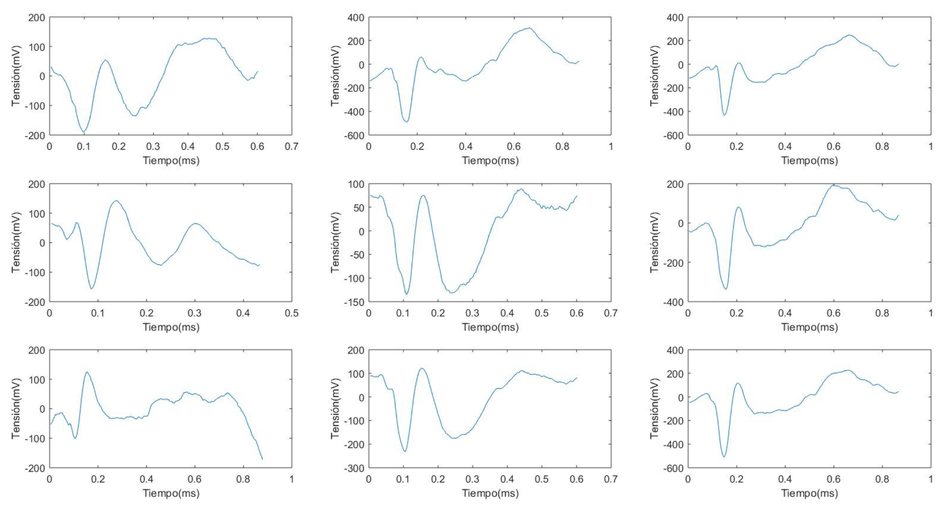
Abstract

Appropriate diagnosis and treatment of epilepsy is a main public health issue. Patients suffering from this disease often exhibit different physical characterizations, which results from the synchronous and excessive discharge of a group of neurons in the cerebral cortex. Extracting this information using EEG signals is an important problem in biomedical signal processing. In this work we propose a new method to identify and characterize patient-specific spike-and-wave EEG epileptic signals. The method is based on the use of trained neuronal networks on probability density function parameters of the translation and rescaling of the Student's t-distribution (location: μ, scale: σ and shape: ν) of pure spike-and-wave-signals. The neuronal network was trained with both normal and epileptic signals. The study resulted in 100% specificity and sensitivity on the studied signals.

Signals Used

EEG Signals Measurement: To obtain the electroencephalographic signals used in this study, 23 electrodes are placed over the scalp like it is shown on the Figure . These electrodes measure the difference in tension between the electrodes establishing the amplitude and direction of the electrical impulse.





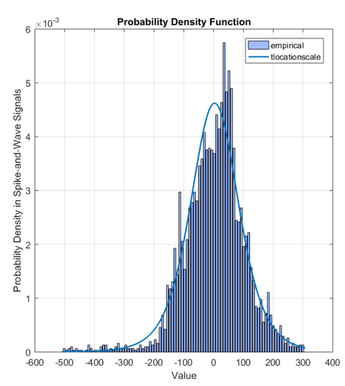
Database: The neuronal network was tested on a validated database from FLENI Hospital. In this work we used 441 spike-wave signals and 339 non-spike-wave signals from 8 subjects. Each signal was edited contain only the spike-and-wave signal. Each input signal used in the neuronal network consisted in 20 randomly assigned signals.

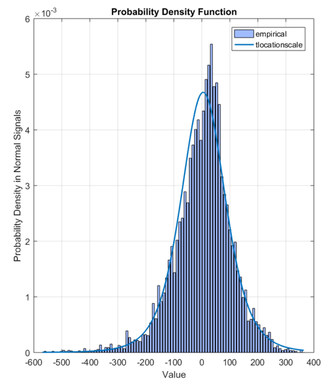
Probability Function Parameters: The parameters σ (standard deviation), ν (degrees of freedom in a Student's t or χ^2 distribution) and μ (mean) were calculated from the translation and rescaling of the Student's t-distribution of both spike-and-wave and non-spike-and-wave signals. Each input signal had these triplet parameter calculated

Neural Network: A neural network based on Matlab 2016a was used to identify the triplet parameter. It was trained with 441 spike-wave input signals and 339 normal input signals. The neural network had 8 neurons and 2 layers.

Probability Density Function Parameters

An example of calculated Parameters of the probability density functions is shown below for both epileptic pattern and normal signals.

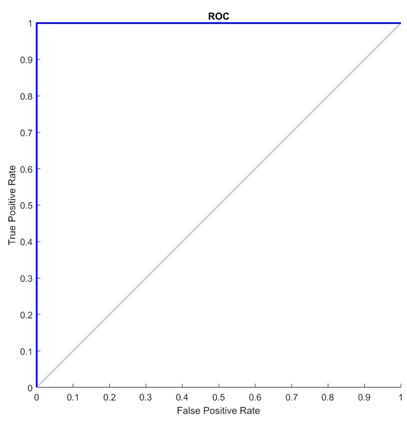




Parameters	μ	σ	ν
Epileptic Signal	4.61	5.90	86.38
Normal Signal	1.33	2.90	46.52

- The difference shown between signals is given by the predominantly skewness of epileptic signals to being positive or negative, given by the spike-and-wave pattern on the signal.
- The amount of degrees of freedom in a Student's t or χ^2 distribution given by ν is about double for the case of epileptic signals since there is a strong pattern within the signal.
- The neural network was trained over these parameters calculated.

Results and Discussion



The trained neural network successfully classified 28 input epileptic and normal signals accordingly. The epileptic input signal consisted on a total of 441 Spike-and-Wave individually identified. This gave 100% specificity and sensitivity.

In future directions, an automatic epileptic identification software will being developed in order to aid neurologists in the quick identification of certain epileptic patterns in patients. Other methods may be included to reassure the outcome such as empirical wavelet-based algorithms or autocorrelation.

Acknowledgements

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