Novel method based in fuzzy clustering for EEG signal analysis

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Introduction

The signals from an **E**lectro**E**ncephalo**G**ram, EEG for short, are well known for being highly subjective and may appear at random in the time scale. These are the main reasons for extracting and analyzing EEG signal parameters using computers as more efficient in diagnostics. With this motivation, nonlinear methods have been proposed to extract parameters for analysis and classification of time series signals. The Higuchi fractal dimension (HFD) parameter [2] measures the complexity, and the chaotic nature of the time series signals. The sample entropy (SampEn) is a statistical parameter to quantify its predictability [4].

New methods have been proposed for the analysis and simplification of the original time series captured, for instance, by the electroencephalography procedure. Among others, the **E**mpirical **M**ode **D**ecomposition (EMD), developed by Huang et al. [1], has been applied to nonlinear and non stationary signal analysis. The EMD method objective to break down the signal in **I**ntrinsic **M**ode **F**unctions (IMF), without leaving the time domain.

A novel method is proposed in this study with the objective of extracting a single IMF function from the **O**riginal **T**imes **S**eries (OTS). This function, that we denote as ESF (extracted simplifyed function), matches the HFD and the SampEn parameters of the OTS, with a small absolute difference error as a validation of the method. A fuzzy clustering based in Gusftason and Kessel algorithm [3] is applied to the time series interpreted as a time-output system, that divides the temporal universe in subsets containing the highest degree of memberships information, obtained from the clustering procedure. From there, and using the Hilbert –Huang transform (HHT), the amplitude modulation bandwidth (BAM) and frequency modulation bandwidth (BFM) are extracted from analytic representation of the single IMF. Furthermore, a new procedure of fuzzy clustering is perform with the

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parameters obtained to conclude an effective classification of EEG signals in three types: normal, not normal or unknown.

Methods and results

The OTS used to apply the new method is a real data extracted from [5]. The results of the computational elapsed time (CET) for the fuzzy clustering process (FCP), for the calculation of the HDF and SampEn parameters of each data (OTS and ESF), the final results of this calculations, and the validation absolute error (VAE), are described in Table 1.

Table 6.2: Informative table of the results in simulations.

	CET (sec)	HFD	SampEn	VAE
FCP	2.052			
Original time series	0.053	1.41617	1.41616	0.00001
Simplify time series	2.720	0.6215	0.6217	0.0002

The graphic of the OTS together with the ESF obtained by the fuzzy clustering method, are shown at the top of Figure 1, and in the same Figure 1, both curves are shown in different plots.

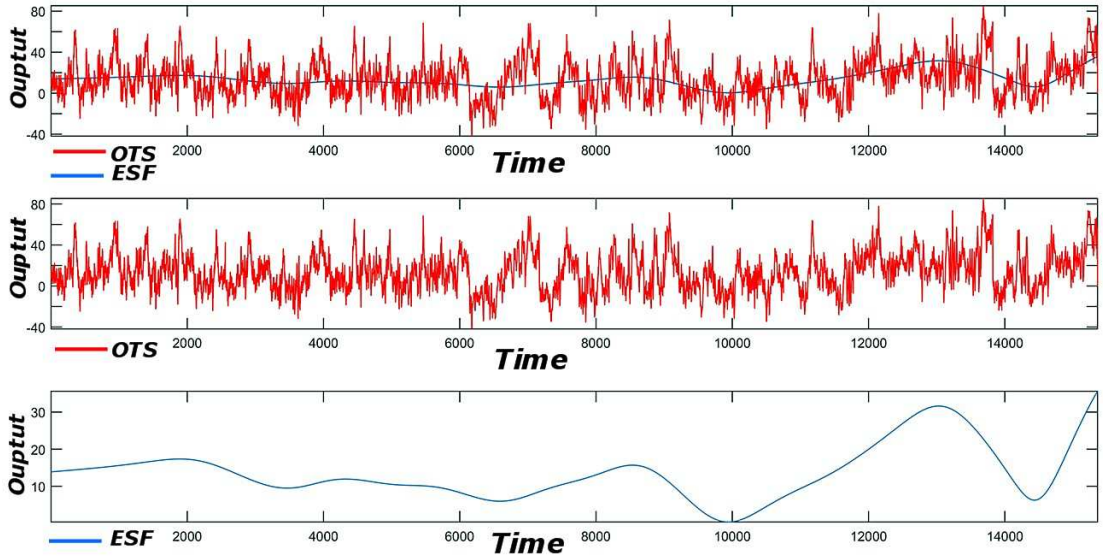

Figure 6.6: Top: OTS (red output) and ESF (blue output); middle plot: OTS; bottom plot: ESF.

Next step is to apply the HHT transform follows by the new application of the FCP for the classification of the EGG signal. This second step of the research is already complete. Due to the small space of this abstract it will be presented at the congress communication.

Conclusions

Promising results encourage to improve the technique of extracting a single intrinsic mode function from fuzzy unsupervised learning technique, in order to analyze and submit to the whole procedure of classification of EEG signals through the Hilbert - Huang transform. A new procedure of fuzzy clustering, is finally perform with the parameters obtained concluding in an effective classification of EEG signals in normal, not normal or unknown.

Referências

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