Complexity

Special Issue on
Advanced Methods to Analyse the Complexity of the Brain

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The brain, while functioning, generates a bioelectromagnetic field due to the synaptic action associated with the interaction between neurons. Brain activity is also associated with changes in the cellular metabolism and blood flow. Such bioelectromagnetic and metabolic activities can be detected through proper neurophysiological measurements. The spatio-temporal dynamics of the recorded neurophysiological signals are closely related to age of the subject, to her/his state of consciousness, to cognitive activities, to the execution of active or passive task (e.g., hyperventilation or external stimulation), to the presence of neurological disorders, to the possible use of medical treatment, and so on. Therefore, the detection and subsequent processing of the neurophysiological signals can provide valuable information about the system that generated them.

There are possible neurophysiological acquisition systems: Electroencephalography (EEG), Electrocorticography (ECoG), Magnetoencephalography (MEG), Local Field Potentials (LFP), Event-Related Potential (ERP), Computed Tomography (CT), and functional Magnetic Resonance Imaging (fMRI). The data recorded by the above-mentioned techniques deeply differ from each other; however, they all are a representation of the output of a complex system: the brain.

The brain is a complex system at least from two perspectives: globally, since it consists of several components dynamically interacting with each other and locally, as the temporal complexity analysis of univariate times series resulting from a single channel recording can provide information about the local dynamics. Intuitively, complexity in signals or images is associated with meaningful structural richness. In the complexity literature, it is hypothesized that healthy individuals or systems correspond to more complex states due to their ability to adapt to adverse conditions, exhibiting long range correlations, and rich variability at multiple scales, whereas aged and diseased subjects or systems may present complexity alterations, depending on the disease. To quantify the complexity of signals, a number of univariate and multivariate multiscale entropy methods, nonlinear synchronization measures, complex network models, and many others were introduced. These methods have been broadly and successfully used in different fields, including biomedical and mechanical engineering, to detect aged and diseased from healthy subjects or systems.

This special issue aims to attract relevant contributions, both methodological and applications, in the field of complexity analysis of neurophysiological data. Contributions on the application of complex network models to the above-mentioned signals, as well as to structural and Magnetic Resonance Images (MRI) and Diffusion Tensor Images (DTI), are welcome.

Potential topics include but are not limited to the following:

- Univariate and multivariate (generalized) multiscale sample and fuzzy, permutation, and dispersion entropy-based complexity descriptors
- Lempel-Ziv complexity-based methods
- Complex network models
- Nonlinear measures of synchronization between neurophysiological signals
- Neural Mass Models to simulate EEG/MEG signals
- Brain connectivity
- Neurophysiological measurement of cognitive abilities
- Neurological disorders
- Cognitive disorders
- Sleep disorders
- Consciousness
- Brain Computer Interfaces

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Papers are published upon acceptance, regardless of the Special Issue publication date.

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