Functional Connectivity for BCI: OpenViBE implementation

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A possible way of interpreting electroencephalography (EEG) data is in terms of functional connectivity between channels, describing how brain areas mutually interact. Brain connectivity can be modeled as graphs, and mental states have been shown to be characterized by particular graph statistics (e.g. node strength or node efficiency) (1). Linking connectivity features to mental states can be a path to enhancing BCI performance.

OpenViBE is an open-source C++ based framework allowing real-time acquisition and processing of EEG data in a modular way, but algorithms and solutions for measuring and post-processing connectivity information are missing.

Based on previous works (3) , we implemented different connectivity algorithms in OpenViBE: magnitude squared coherence and imaginary part of coherence (2). We ensure low complexity by using the Eigen library (4) for algebraic operations, and implementing Welch's method (5) for computing the periodograms. We also developed matrix manipulation methods for post processing, and Graph Laplacian « denoising » (3).

We show this implementation is feasible for real-time Motor Imagery experimental protocols, as computing a single connectivity measure across 2 seconds of signal sampled at 512Hz, using 74 channels and 128 frequency bins takes less than 25ms on a typical workstation. When using 256 channels, this measure takes approximately 150ms, and 300ms when also using 256 frequency bins.

Research is currently ongoing to use functional connectivity as the basis for graph representation of the underlying brain networks, or with classification algorithms as an alternative feature to spectral power to discriminate between different Motor Imagery tasks: rest vs activity.

References

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