A Novel Framework for Spatiotemporal Quantification of Neuronal Functional Connectivity

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Many behavioral and cognitive processes are associated with spatiotemporal dynamic communication between brain areas. Thus, the quantification of functional connectivity with high temporal resolution is highly desirable for capturing in vivo brain function. However, brain functional network quantification from neural recordings has been commonly used in a qualitative manner or by means of graph-theoretical measures with uncertain neurological relevance and novelty value.

The hypothesis that neuronal oscillations in general, and inter-areal synchronization of these oscillations in particular, are instrumental for normal brain function has resulted in widespread application of quantitative methods to evaluate neuronal synchrony or dependencies in EEG data.

In this paper, we describe a novel framework for spatiotemporal quantification of neuronal activity. Our methodology models bivariate joints from assuming pairwise communications to be realizations of a random variable. Given this assumption, we estimate a density function and quantify its changes over consecutive windows of time by means of information divergences. This results in a simple two-dimensional matrix indicating the location in time and space of relevant neuronal events. The proposed divergence-based framework of functional connectivity quantification is addressed for temporal dependencies of functional networks that can be related to a cognitive task.

Validation of our methodology has been successfully achieved by use of synthetic EEG data. On the other hand, preliminary results show that for human EEG recordings of a
visual-motor-driven cognitive task, we are able to quantify cognitive states for the average subject in space and time. In addition, this methodology can be used online and as input to clustering techniques in order to separate people by their cognitive states. Further statistical analyses can be pursued to measure significant differences between populations/conditions (e.g. healthy/disease, task/rest).

REFERENCES
