Abstract

Electroencephalography (EEG), a technique with merits in term of simplicity, accessibility and temporal resolution, has been subjected to a renewed interest in the recent years. The high temporal resolution of the EEG can be used effectively to address quick changes in the brain activity during some tasks. With the present trend of computational methods and resources, it is now possible to build cortical activation maps describing the activity of the brain during the execution of an experimental task such as meditative relaxation. However, simple imaging of brain regions activated during particular tasks do not convey the information of how they are functionally interconnected during the execution of the task. The concept of brain connectivity could play a vital role in assessing inter-region and intra-region interactions of the brain. Several definitions of connectivity, i.e. functional and effective, have been adopted in literature to this effect.

Meditative relaxation has been revealed to improve attention and emotion regulation. However, the mechanisms accounting for these effects are mostly unidentified. In order to make further advancement in this direction, an extensive interdisciplinary study is the need of the hour. This thesis is the outcome of such an approach, where the EEG data has been collected from two groups of subjects and extensively analyzed. The experimental groups are formed with the Kriya Yoga meditators and non-meditators or control subjects. Kriya Yoga is a very ancient Indic method, practiced by people from all over the world. A derived form of these methods namely Kriya Yoga based Meditative Relaxation (KYMR) has been adopted in this thesis. The signal processing and analysis steps proposed in this thesis involve preprocessing, data compression, connectivity estimation and validation. The raw EEG signals have been acquired while the subjects undergo KYMR. Then the EEG signals have been pre-processed to obtain clean and artifact-free signals. In this step, Dynamic Time Warping (DTW)-based motifs search algorithms have been proposed as efficient methods for removing the ocular and muscular artifacts. The effectiveness of this method has been compared with the other state-of-the-art artifacts removal techniques. These signals are subjected to an extended MVAR model-based brain connectivity estimation. The proposed method has also been compared with the other brain connectivity methods from the literature. Sparsity-based inter- and intra-brain region connectivity analysis has also been performed for the estimation of directed source information flow between sparsely connected sources. Another contribution of the research is a byproduct of the data management where a Generalized Multivariate Auto-Regressive (GMVAR) and modified context-based multichannel compression algorithms have been developed to compress the huge quantity of data generated during the experiments. These methods have been validated with the standard algorithms from the literature.

Keywords: EEG, Meditation, DTW, Brain connectivity, Multivariate auto-regressive model, Partial directed coherence, Sparsity.