UNIVERSITY OF WARSAW

Abstract

Biomedical Physics Division
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PhD

Study of the dynamics of bioelectrical activity of the brain using methods based on blind source separation

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Event-related potentials (ERP) are brain responses to given stimuli observed in the electroencephalogram. They are a valuable tool for the non-invasive study of the human brain. The diagnostic strength of analysis of ERPs comes from the accumulated over years observations of correlations between the latency and amplitude of positive and negative deflections of the average ERP and the behavioral or clinical state of the subject. However, the synchronous electrical activity of neurons in a patch of the cerebral cortex can be approximated by the current dipole. Each of such dipoles can be treated as a source, contributing—a component—to the measured electric potential distribution on the head surface. The potential measured at the scalp could be viewed as a weighted sum of such components.

The main aim of the research presented in this thesis was to develop a new method for the automatic decomposition of multi-channel ERP recordings. The specificity of the algorithm is based on explicitly taking into account the physical model of ERP generation. There are two promising approaches to the decomposition of a multivariate time series into components: blind source separation, providing spatial separation and matching pursuit used to parametrize structures in the time-frequency domain. The methodology proposed in this thesis incorporates the best properties of both algorithms. It reduces some of the drawbacks that each of the methods has when employed separately. Some modifications were necessary to apply these techniques successfully. Those are discussed in great detail within this thesis.

The procedure proposed here results in a precise spatial-time-frequency filter. Results of applying this filter are presented in this thesis. The technique, based on physically reasonable assumptions, permits accurate analysis of evoked potentials components. Three experiments were conducted in order to demonstrate the usefulness of the method. In particular, a comprehensive study of the dynamics of steady-state evoked potentials shows all the advantages of the proposed method.