SUMMARY OF Ph.D. DISSERTATION

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Title

A Study on Improvement of Dipole Estimation in MEG Measurement

Abstract

In this paper, a noise reduction method and an estimation of brain activity in MEG (magnetoencephalography) measurement are proposed.

In the signal processing in MEG analysis, the imposition of the burden to the patients due to the noise reduction with averaging across many trials is the issue. Though the MEG analysis with ICA (Independent Component Analysis) may resolve the issue, it is slightly problematic by the influence of the independent sensor noise.

A sensor-noise reduction method, which is a combination of a Kalman filter and factor analysis (FA-processed Kalman filter), is proposed. The Kalman filter eliminates the sensor noise in MEG data: the state-space model for the Kalman filter is constructed with the forward solution of the MEG measurement. The approximations of the noise covariance matrices are provided by factor analysis. Some numerical experiments show that the FA-processed Kalman filter effectively eliminates the sensor noise, and it is robust to the error in the number of the common factors in factor analysis. These features relieve the issues in ICA.

In the inverse analysis, i.e. the estimation of the current density distribution in a brain, the dependence to prior information and to temporal information, the covariance of the MEG data is the issue to be addressed. A spatial filter without using temporal information is proposed. The cumulants of the second and fourth orders are employed for the design of the spatial filter. Numerical experiments show the fourth-order cumulants improve the localization of the estimated current distribution. The reconstruction of the current distribution estimated by the spatial filter with multiple linear regression (spatial filtered reconstruction: SFR) assists the spatial filtering. With the Cp statistic, which is a criterion to select the optimal regression model, the redundant dipoles in the distribution are removed. In the numerical experiments, the current density distribution was localized effectively and reasonably by the reconstruction with the objective criterion.

The FA- processed Kalman filter and the SFR were performed in the single-trial AEF analysis. The activities in the brain were successfully estimated by the combination.