A fast EEG forward problem approximation method and its application to tissue conductivity estimation

Key words: EEG forward problem, EEG inverse problem, conductivity estimation, lead field matrix approximation.

Bioelectric source analysis in the human brain from scalp electroencephalography (EEG) signals is sensitive to the conductivity of the different head tissues. Conductivity values are time and subject dependent, so non-invasive methods of conductivity estimation are necessary to fine tune the EEG models. In this work, we aim at estimating conductivity while solving the EEG source localization problem. To do this, we need to compute a forward EEG problem solution (so-called lead field matrix) for a large number of conductivity configurations.

Computing one lead field requires a matrix inversion which is computationally intensive for realistic head models. Thus, the required time for computing of a large number of solutions quickly becomes impractical. In this work, we propose a method which allows us to approximate the lead field matrix for a set of conductivity configurations, using only the exact solution for a small set of basis points from the conductivity space. Our approach accelerates the computing time, while the approximation error remains controlled.

Our method is tested for brain and skull conductivity estimation, with simulated and real EEG data. In the case of real data, we process EEG evoked potentials of median nerve stimulation. We used a single-dipole model to estimate both source location and conductivities of brain and skull. Our approximation method offers a performance similar to using exact lead field matrices, but with a remarkable gain of time.