Dipole reconstruction in MEG and EEG with different model geometry.

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Abstract

Despite the growing interest in realistic modeling, the spherical model is still widely used in practice, especially for locating neural sources underlying MEG components.

Estimating the bias between realistic and spherical model could help deciding in which case a spherical model might not provide a suitable accuracy.

The work presented here aims at evaluating this bias using a computer simulation.

MEG forward problem has been solved for about 2000 dipoles located on the brain surface using a very fine three-layer realistic model of the head and the boundary element method (BEM). For each dipole, spherical models, one-layer realistic BEM models and coarser three-layer realistic BEM models were used to reconstruct the dipole.

Localization and orientation errors highly depended on the dipole position in the brain.

It was found that the localization bias induced by using a spherical model of the head increased from 2.5 mm in the upper part of the head to 12 mm in the lower part, on average (Fig 1). It was also found that, for the same computing time, a three-layer model of the head gave on average 2mm better localization errors than a one-layer model of the head.

The vertical position effect can also be observed in EEG: the localization bias induced by using a spherical model of the head increased from 4.3 mm in the uppermost part of the head to 21 mm in the lower part, on average (Fig 1).

The use of a local sphere fitting the part of the scalp in front of a subset of coils gathering most of the signal improved the localization error of 1 mm compared to a global sphere for dipoles situated in the upper part of the head. However in the lower part of the head the determination of the local sphere with respect to channels of maximum signals is more complicated since our full-head MEG sensors configuration does not well cover the magnetic field topography in this area.

Most importantly, we found in our noiseless simulation that the three-layer realistic MEG model could retrieve the orientation within 20 degree. This was not the case with spherical and one-layer realistic models. In EEG, orientation errors remain under 20 degree with an average of 7 degree for both the spherical and realistic model.

Realistic models also enable easier coupling of both MEG and EEG signals when solving the inverse problem. This was also evaluated.

Figure 1: Mean localization and orientation for spherical and 3-layer realistic models. Dipoles are situated in 10 horizontal slices, slice number 1 being the uppermost.
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Introduction
Several geometric models of the head can be used for the MEG forward problem:

- spherical model: fast analytic computation.
- realistic model: slow numerical computation.

Goals of this study:
- Evaluation of the bias produced by the use of a spherical model on simulated data obtained with a realistic model.
- Is one layer sufficient?
- Can the radial component of the dipole sources be retrieved?

Methods

- Localization error: 2-12 mm with a spherical model depending on dipole position (along the vertical axis) and orientation.
- For the same computing time a rough 3-layer model is more accurate than a fine 1-layer model.
- Orientation error: < 20° when using a 3-layer realistic model even with radial dipoles.

Results

- One layer
- Three layers
- Spherical models: fitting the scalp
- Global sphere
- Local sphere
- Spherical models: fitting the brain
- Global sphere
- Local sphere
- Realistic models: one layer
- Local sphere
- BRAINLOCSPH
- GLSPH

- Realistic inverse models:
- One layer
- Three layers
- BRAINGLSPH
- GLSPH

- Combined MEG and EEG
- Influence of noise

Previous results

- Error along tangentiality
- Error along vertical axis

- EEG reconstruction error
  (Yvert et al., 1997)

- Preliminary result

Combined MEG and EEG

Simulation with 1 dipole in a realistic model (REF)

Inverse problem: MEG: brain-fitted sphere (BRAINLOCSPH)
EEG: global sphere (GLSPH).

Evaluation of localization error with confidence intervals:
noise added on electrode and MEG helmet positions (400 repetitions).