Simultaneous MEG and EEG Beamformer – Source Suppression Strategy for Localizing Highly Coherent Sources

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Abstract—Simultaneous magnetoencephalography (MEG) and electroencephalography (EEG) analysis have great advantages over MEG or EEG-alone analysis. For effective simultaneous analysis, MEG and EEG data should be combined in order to have maximum synergistic effects. We proposed recently simultaneous MEG and EEG beamformer analysis, which can localize both radial as well as tangential components, while single-modality analyses (MEG-alone and EEG-alone) are hardly to detect them. In practice, most brain activities of neuroscientists’ great interest are coherently activated; however, conventional beamformer cannot work well for such coherent sources due to its inherent weakness. As a possible solution, a linearly-constrained minimum variance (LCMV) beamformer may be used with a source suppression strategy to overcome this weakness. In this work, we first formulated LCMV beamformer for simultaneous MEG/EEG analysis using source suppression, which is a bit different from the conventional simultaneous analysis. Its capability over various suppression strategies were thoroughly investigated from both numerous simulated data and empirical data.

I. INTRODUCTION

Magnetoencephalography (MEG) and electroencephalography (EEG) have been greatly interested in neuroscience. MEG and EEG have so high temporal resolutions that they could detect rapidly changing brain activation. They measure different physical information; however, they have the same underlying physics and try to detect the same electrical sources in the brain. For this reason, an integrative MEG and EEG approach for simultaneous analysis is appealing. Among various MEG/EEG simultaneous source localization methods, a beamformer for simultaneous MEG/EEG analysis was proposed under the assumption that sources are almost uncorrelated (Ko et al., 2010). In this work, we firstly formulated simultaneous MEG/EEG beamformer incorporating source suppression strategy, which is quite effective in localizing highly coherent sources. Particularly, we focused on doing extensive study over various source suppression strategies. These extensive studies provided a deeper understanding of strategic simultaneous analysis for localizing coherent sources. To the best of our knowledge, this kind of work has been lacking.

II. METHOD AND RESULT

Let the defined \( \Omega_C \) be the local region in which the coherent sources exist. Then, assuming the total of \( J \) position vectors (voxels) are located within the cluster \( \Omega_C \) and the locations of these voxels are defined as \( r_{1}, r_{2}, \ldots, r_{J} \). Then, the \( N \times 3N \) constraint matrix is defined as

\[
L = [L_{r_{1}}, L_{r_{2}}, \ldots, L_{r_{J}}]
\]

Defining an \( N \times (3+3J) \) matrix

\[
\hat{L} = [L, L_{\Omega}]
\]

the beamforming weight vector and output power are expressed as

\[
W(t) = \Sigma^{-1}\hat{L}(r)[L^T \Sigma^{-1} L(r)]^{-1} \cdot \hat{Q}(r, t) = [L^T \Sigma^{-1} L(r)]^{-1}.
\]

Here, \( s \) is a unit vector selecting one of the components of the lead-field vector of interest, and \( L \) is lead-field matrix.

We generated 2600 two-dipole problems (SNR of 5dB) to examine the feasibility of our proposed approach. Figure 1 presents the average source localization error over various source correlations (phase difference between sources varying from 0° to 90°), with respect to various source suppression strategies, such as point, spherical region of radius 5 mm, 10 mm, 20 mm, and 25 mm to avoid power-leakage interference between coherent sources. The conventional beamformer approach is represented by the solid circular line.

![Figure 1. Average source localization error over various source correlations (phase difference between sources varying from 0° to 90°), with respect to various source suppression strategies.](image)

REFERENCES


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