DIPOLE LOCALIZATION ERRORS DUE TO NOT INCORPORATING ANISOTROPIC CONDUCTIVITIES IN REALISTIC HEADMODELS

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Abstract

Many source localization methods neglect the anisotropic conductivity of brain tissues, although it has a big influence on the localization problem. In this study, we evaluated the dipole localization error due to neglecting the anisotropic properties of the conductivity in a realistic head model (built from T1 and diffusion tensor MRI) calculated using a FDM method. Results show that the mean dipole localization was on average 9.3 mm. Moreover the large errors were found te be at the edge of the soft brain tissues. We therefore conclude that the incorporation of anisotropic conductivity is necessary for an accurate localization of the dipole.

1 Introduction

Electroencephalogram (EEG) dipole source localization has been proven its usefulness in the presurgical evaluation of patients suffering from epilepsy. The problem can be subdivided into two problems: (1) by solving the forward problem we obtain the electrode potentials given a dipole source in a specific head model, (2) by solving the inverse problem we estimate the optimal dipole components that minimize the difference between the electrode potentials measured at the scalp and those provided by solving the forward problem.

Head models with isotropic conductivities are typically used. In reality the skull, white matter and grey matter have an anisotropic conductivity. In this study we want to investigate the dipole localization error due to not incorporating anisotropic conductivities.

2 Methods

Head model: The head model was constructed by segmenting a T1 MR image. The anisotropic conductivity of the skull was set 10 times larger in the tangential direction than in the radial direction. The anisotropic conductivity in the white and grey matter was derived from diffusion weighted MR images. The direction facilitating the diffusion of water is also the one with the highest conductivity. The anisotropic conductivities of skull, white matter and grey matter were derived from the isotropic conductivity according to the *volume constraint* [1].

Forward problem: The forward problem is calculated using a finite difference method where anistropic conductivities can be incorporated using tensor calculus [2]. In an XY-, YZ- and XZ-plane, we placed 3 dipoles (along the X-, Y- and Z-axis) in each voxel belonging to the white and grey matter of the brain.

For each dipole the forward problem was solved in a head model with anisotropic conducting skull, white and grey matter compartments. This resulted in a set of electrode potentials.

Inverse problem: The electrode potentials were then used to solve the inverse problem in a head model where the conductivity of the skull, white matter and grey matter was set isotropic. This resulted in a new dipole localization and orientation estimate. By taking the Euclidian distance between the estimated dipole and the original dipole, the dipole localization error was investigated due to neglecting the anisotropic conductivity of skull, white matter and grey matter.

3 Results

Results show that the dipole localization errors had a mean of 9.3 mm (max.: 33 mm) and a standard deviation of 3.7 mm.

4 Conclusion

Not incorporating anisotropic conductivity of brain tissues in a realistic head model results in large dipole localization errors, although the localization errors are not as high as studies performed in analytical head models [2]. Therefore, it is necessary to include the anisotropic conductivity in head models for EEG source localization.

References

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