

Accurate skull modeling from MRI for EEG source localization

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Abstract

In EEG source localization, the skull plays an important role due to its low conductivity compared to other tissues in the model and due to its inhomogeneity as thickness and conductivity varies throughout its structure. While MRI is the most used imaging modality for the visualization of the head structure, it does not allow an exact distinction of the skull and its tissue types. Conversely, CT is the modality that can accurately describe the geometry of the skull but is not commonly performed on patients due to ionizing radiation. We investigated the effect of using MR-based models for the skull as opposed to a ground truth CT-based skull model. A head model with an accurately segmented skull from CT, including compact and spongy bones as well as air cavities, was used as reference. To analyze the influence of using MR-based skulls, 4 models were constructed with skull geometry and air cavities segmented from MRI using SPM toolbox: M1 – isotropic inhomogeneous, the spongy bone was modeled as eroded compact; M2 – anisotropic homogeneous; M3 – hybrid, isotropic inhomogeneous in the vault (as M1) and anisotropic in the base (as M2); M4 – isotropic homogeneous.

The forward problem was solved through FDM with Reciprocity using 128 electrodes. The estimated dipole parameters were chosen as the ones that best fitted the surface potential. Large errors in the temporo-basal region were seen in Figs. 1(a) and 1(d) where the difference in shape between MR and CT-based skulls is particularly noticeable. In Fig. 1(b), the errors were smaller in the basal region but more distributed in the whole volume. The hybrid model, Fig. 1(c), showed overall lower errors. When the geometry of the skull cannot be accurately segmented, the isotropic inhomogeneous model (M1) can better model the cranial vault but anisotropic conductivity (M2) is appropriate in regions such as the skull base. Then, for a patient-specific MR-based head model, the skull will be better modeled as in M3.

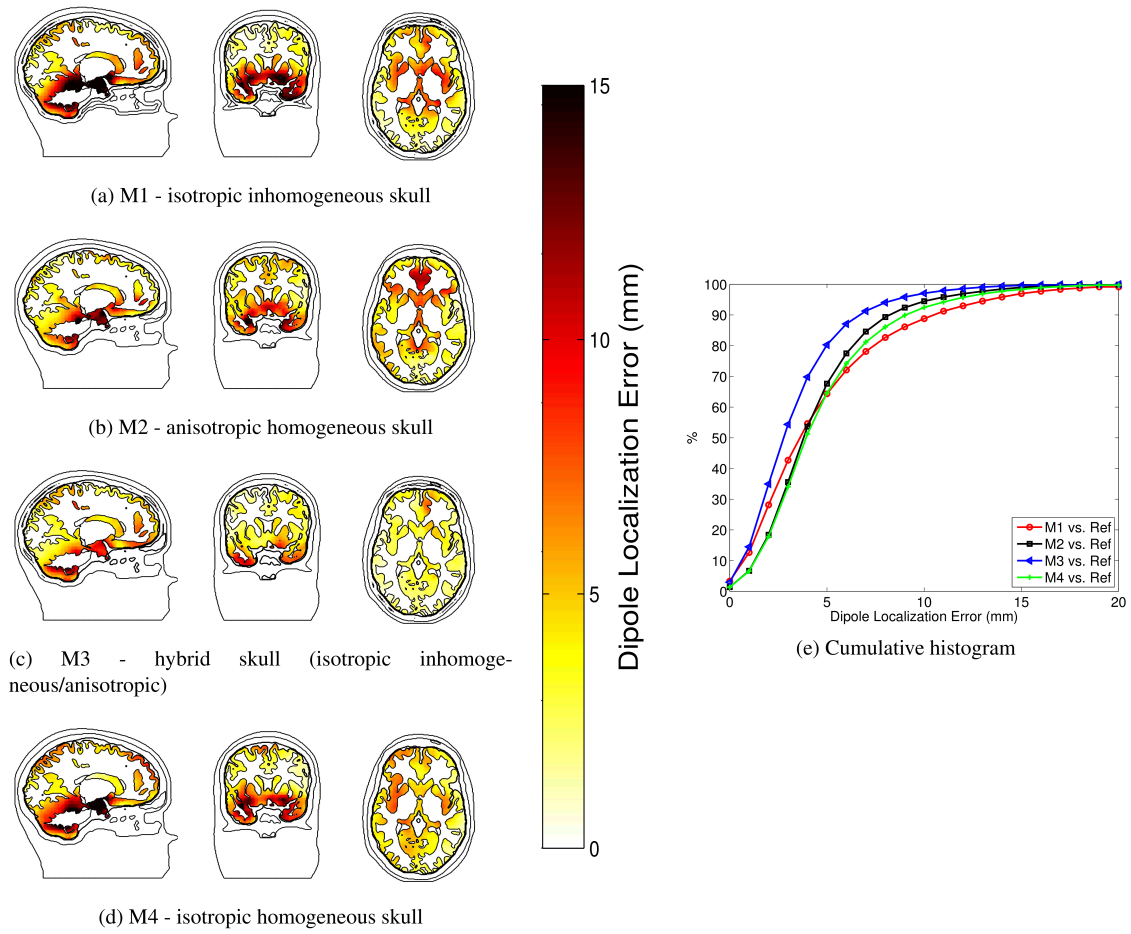


Figure 1: Localization error for models 1 to 4.