Age-specific Template Head Models for EEG Source Analysis

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I INTRODUCTION
I. Incorporating the realistic anatomy of the head into the solution of the EEG forward problem improves the accuracy and reliability of EEG source analysis [1]. Individual realistic head models can be derived from the subject’s MRI. In infants and children MRI data are often difficult to collect. However, source analysis accuracy would particularly benefit from realistic head models in children, as head tissue structure differs vastly from adults. A solution might be to use age-specific template models representing the child-typical anatomy.

In this work, we describe a pipeline for EEG source analysis with age-specific head model templates. In addition, a study is presented demonstrating the feasibility of the template models.

II MATERIALS and METHODS

Template Model Creation

- Averaged T1 and T2 MRIs from the Neuro-developmental MRI Database [2] for different age groups [3,4,5]
- Electrode coregistration to segmented scalp [6]
- Markov Random Field segmentation of most relevant head tissues for ages 6 and above [7]
- Generation of 1mm geometry-adapted cube meshes [8]
- Pre-computation of lead field tables for sources on regular 2mm grid covering the whole brain
- Second order Bezier spline interpolation to interpolate leadfield for sources not lying on grid [9]
- Spherical spline interpolation to interpolate voltages to recorded electrode configuration

Simulation Study

- Reference model created from individual MRI of 12 y/o subject using established pipeline
- Simulation of reference data for sources at 12 positions with radial and tangential orientation
- Source reconstruction of reference data in age-specific template models and ellipsoidal model
- Assessing mean localization error

Evaluation with Interictal Spike Data

- Real, epileptic spike data of same subject
- Dipole fit to rising flank of peak with fixed alpha source
- Comparison of Talairach coordinates of reconstructed sources for individual FEM model, realistic template models, and ellipsoidal model

III RESULTS

Simulation Study

- Min. error (5.0mm) for age-appropriate template model (12 years)
- Ellipsoidal model yields larger error (13.2mm) than age-appropriate template
- Age-specific template models for younger age groups exhibit larger localization errors

Evaluation with Interictal Spike Data

- Individual FEM model localizes close to lesion visible in MRI
- Age-appropriate template model reconstructs source in close vicinity of source reconstructed by individual FEM model
- Fitted dipoles for older age-groups (> 6 years) clustered together

IV CONCLUSION and OUTLOOK

Age-specific realistic template head models, as described here, allow the effortless analysis of EEG data taking into account at least the typical anatomical features of the head even when no individual MRI data are available. Using the age-appropriate template model substantially improves source reconstruction as compared to an ellipsoidal model.

In conclusion, we recommend using the realistic template models when accurate source localization is desired but no individual MRI data are available.