INTRODUCTION

Individual, realistic volume conductor models improve EEG source analysis accuracy. Still, these models have not found widespread application in the EEG community. Reasons for this are the challenges of tissue segmentation and mesh generation. Here, we are presenting a complete pipeline for creating and using individual, realistically shaped head models for EEG source analysis. Minimal user interaction is required, and computations are sufficiently fast. The efficacy of our pipeline is demonstrated on two exemplary data sets showing that the more realistic head models improve the source reconstruction compared to a spherical model and a standardized, realistic model.

II MATERIALS and METHODS

MRI Pre-processing
- Reading MRI and input of user-defined landmark points ~3 min user interaction.
- Robust scalp surface reconstruction (Fig. 1) using multi-resolution Active Regions approach [2].
- White matter segmentation and cortex surface reconstruction (Fig. 1) using Markov Random field (MRF) classification [3].

Mesh Generation and FEM Leadfield Computation
- Geometry-adapted hexahedral FV mesh generation [6].
- FE mesh resolutions of 2 mm and 1 mm possible.
- Simplification of CSF compartment to avoid problems with complex source spaces and inverse methods [7].
- Source space information derived from brain compartment of FE mesh.
- Leadfield computation on regular, 2 mm grid covering entire brain.
- Venetian dipole source model.
- Fast and memory-efficient row-wise leadfield computation employing transfer matrix approach [8].

Volume Conductor Segmentation
- Segmentation of tissues most relevant for volume conduction.
- First, segmentation into 9 different tissue regions using newly developed method [4].
- MRF model representing layered structure of head tissues (Fig. 2).
- Tissue probability atlas based on distances to reference surfaces.
- Optimization of image parameters and labels using Expectation-Maximization type procedure and Iterated Conditional Modes algorithm [5].

III RESULTS

Source Analysis of Basal Temporal Lobe Epilepsy
- Patient with basal temporal lobe epilepsy.
- Dipole source analysis with three different head models:
  - Four-shell ellipsoidal
  - Standard FEM model
  - Individual FEM model
- Reconstructed location with individual FEM best fits the expected spike location.
- Other models result in too superior source locations.
- Dipole orientation for individual FEM also consistent with general curvature of cortical surface.

Source Analysis of Auditory N1
- Auditory oddball paradigm.
- Standard condition with frequent simple tone at 1200Hz.
- Two head models:
  - Four-shell ellipsoidal
  - Individual FEM head model
- Fit two symmetrical regional sources.
- Fit interval: 80 to 110 ms (N1).
- Sources reconstructed close to Hesch’s gyrus for the individual FEM model.
- Reconstructed source positions too superior for ellipsoidal model.

IV CONCLUSION and OUTLOOK

The presented pipeline allows effortless creation of realistically shaped, individual head models for EEG source analysis. Due to the minimal required effort, individual models hopefully will find a more wide-spread application facilitating improved source localization accuracy for EEG source analysis.

In the near future the pipeline will be extended to be also applicable for MEG data. In addition, further segmentation tools will be integrated. Those tools will help to improve the segmentation for children and subjects with pathological anomalies (lesion, skull hole, ...).