P028_Automatic MRI Based Generation of Head Models for EEG Source Analysis

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EEG source analysis greatly benefits from using individual, realistically shaped head models for the solution of the forward problem [3,6]. Routine application of individual models is still impeded by the difficulty of correctly segmenting MRI data, especially bone and cerebro-spinal fluid (CSF). For this reason, we propose a new, automated segmentation procedure on the basis of MR images. The good performance of this approach is demonstrated by exemplary segmentation results and validation against a CT reference segmentation.

The segmentation procedure is formulated in a Bayesian framework in which multimodal image data as well as a-priori information on the anatomy is evaluated to achieve optimal segmentation performance. A Markov random field (MRF) model [4] incorporates the a-priori knowledge that the head can be described as a structure with consecutive layers of eight different tissues.

The optimal segmentation, which best fits the MRF model and the measured data, is determined using an Expectation-Maximization (E-M) type algorithm. Our approach was applied to two exemplary data sets: the first containing a T1- and a T2-MRI, and the second only containing a T1-MRI. The outlines of the segmented regions were overlaid onto the original MRI to show the accuracy of the segmentation. In addition, we computed a segmentation for a third subject where also a CT image was available. A reference skull segmentation was derived from the co-registered CT image. The overlap of the skull segmented from the MR data using the proposed approach and the CT based reference skull mask was quantified using the Dice coefficient $D$ [2].

Visual inspection revealed that scalp, skull, CSF and brain tissue were accurately identified. CSF was precisely delineated even when only a T1-MRI was available. Still, the results indicate that it is advantageous to also incorporate a T2-MRI into the segmentation.

A good agreement of $D=0.86$ was found between the skull segmentation for the third subject and the CT based reference skull. In a comparable validation study [5] previously published skull segmentation approaches only reached agreements of $D=0.75$ and below.

In summary, we propose an automatic segmentation approach, which proves to be accurate especially with regard to skull segmentation. The approach was implemented into an easy-to-use software pipeline allowing the effortless generation of individual, four-compartment realistic head models. By doing so, our development removes a substantial obstacle for the use of realistic head models in EEG source analysis.

References:
4. Li, S. Z. (2009), 'Markov random field modeling in image analysis (Springer).