Zusammenfassung der Dissertation:

'Evaluation of Forward Modeling Inaccuracies and Spatio-temporal Source Reconstruction for EEG/MEG Data Analysis in Human Brain Research'

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In neuroscience, the study of electromagnetic fields is important to understand brain function as these fields mediate between brain sources and noninvasive measurements (electroencephalography (EEG) and magnetoencephalography (MEG)). Anatomical and electromagnetic aspects of individual brains as well as other head tissues influence these fields and therefore EEG/MEG measurements. Two particular topics are important in this context: how the fields are modeled (forward problem) and how their origins can be estimated (inverse problem) based on measurements. Both topics are addressed in this dissertation:

Firstly, one important aspect of forward modeling for EEG is to model the electrical conductivity profile of human skull tissue. Several materials (soft and hard bone, air) with very different electrical conductivities are inhomogeneously distributed, as three layers, across the skull. In the past, this fact has been neglected for modeling purposes. This dissertation shows the importance of skull modeling and inaccuracies (uncertainties) introduced by assumptions on geometry and conductivity distribution. The results are analyzed in terms of statistical error measures (e.g., source mislocalization up to almost 2 cm) and qualitative assessments using visualization techniques. Secondly, to solve the inverse problem and estimate source locations of neuronal activity, uncertainties in the measurements need to be accounted for. Measurement uncertainties based on technical as well as biological sources are contaminating remotely measured signals of the sources. Since the activity of neuronal sources can be sampled over time, spatio-temporal approaches have been introduced to stabilize inverse solutions. This dissertation extends an existing spatio-temporal regularization (STR) algorithm to specifically penalize solution components outside a frequency-of-interest band. The evaluation is rooted in a systematic investigation including computer simulations as well as validation using experimental measurements. In contrast to previous results reported in the literature, the results show that STR can be approximated by simple data filtering. Therefore, more complicated linear methods (such as STR), which require significantly more efforts in implementation and parameterization, do not necessarily perform better.