



Software for Integrated Analysis of NIRS-EEG Data



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Introduction

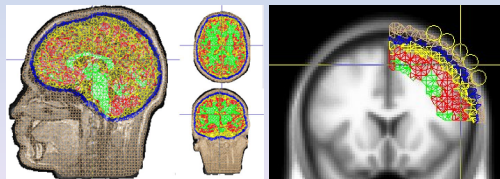
Motivation. NIRS and EEG are physically compatible and functionally complementary modalities for imaging cortical hemodynamic states and electrophysiological activity. *Concurrent* NIRS-EEG should contain useful information not available from either modality alone.

Objective. We aim to develop a software platform for integrated data presentation, analysis, and visualization of cortical reconstructions.

Approach. We leverage the capabilities of two software packages, one developed for NIRS analysis (NAVI) and the other for EEG/MEG analysis (EMSE). Anatomy provides a common spatial framework: electrodes and optodes (sources/detectors) on the head surface are sensitive to cortical activity and states as mediated by brain and head tissues. Experimental data from either modality may be presented topographically on the head surface. Further, volumetric image reconstructions may be derived using computational models, with forward and inverse solution techniques suited to each modality.

FEM Mesh Illustrations

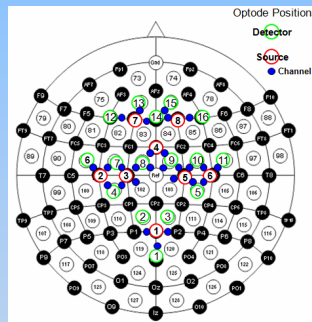
In particular, the *finite element method* (FEM) may be adapted to solve optical (via NAVI) or electromagnetic (via EMSE) forward problems, so that cortical reconstructions may be obtained in a *common space* using inverse techniques suited to each modality. For example, EMSE may be used to generate meshes from individual or standard MRIs:



[Left] A whole-head FEM mesh suitable for EEG source reconstruction techniques is shown for one individual's MRI (tan = scalp; blue = skull; yellow = CSF; red = gray matter; green = white matter)
[Right] Coronal view of a mesh situated beneath an optode array using a standard (MNI average) MRI.

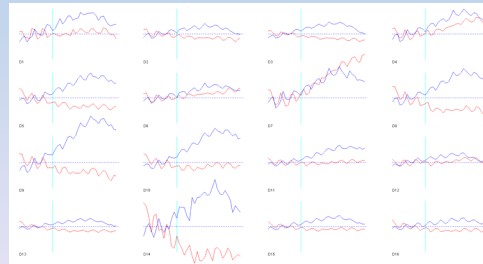
NIRS-EEG Motor Experiment

Task. Subjects seated comfortably were instructed to relax their arms. The experiment comprised 2 blocks of motor execution by means of hand gripping (24 trials per block per condition). Each trial began with a 2-second presentation of a fixation cross. For executed movements, the cross remained in place and the subjects were instructed to open and close their hands with an approximate frequency of 1Hz. Then after 4 s the cross disappeared and the screen remained blank for 10.5 +/- 1.5 s. [1]

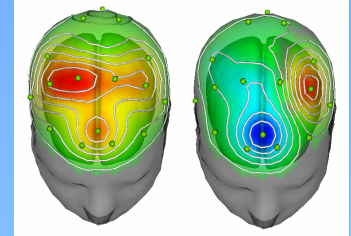


Setup. 8 sources and 16 detectors were used for NIRS acquisition, concurrent with 64-channel EEG acquisition.

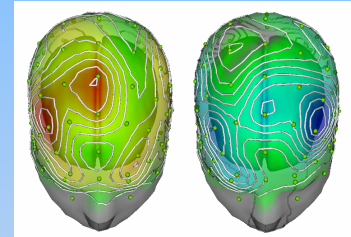
Results



NIRS raw source-detector data were transformed to OxyHb normalized time series in NAVI and read into EMSE. Averages were made at each detector across all sources for the right (red) and left (blue) experimental conditions for 6 s following each trial, using a two-second baseline (vertical line at 2 s).



OxyHb NIRS topographies of time averages (3-6 s) with radial projections to MNI standard cortex for left (left) and right (right) motor conditions (via EMSE).



EEG sensorimotor mu rhythm (8-12 Hz, Hilbert envelope) time averaged (2.5 - 4.5 s) for left and right motor conditions (as above).

As expected, right vs. left motor conditions clearly differ in both modalities; yet results are not bilateral reflections, likely due to hand dominance differences.

Next Steps

Initial steps have been taken to integrate NAVI and EMSE analysis software within a common spatial framework. Next steps will integrate inverse reconstructions using common FEM meshes—thus setting the stage for cross-modal coupling analyses.

References

- [1] S. Fazli, J. Mehnert, et al., "Enhanced Performance by Hybrid NIRS-EEG Brain Computer Interface," submitted to NeuroImage, June 30, 2011
- [2] C.H. Schmitz, D.P. Klermer, et al., "Design and implementation of dynamic near-infrared optical tomographic imaging instrumentation for simultaneous dual-breast measurements," *Applied Optics* **44**, 2140-2153 (2005).

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