A Programmable Laboratory Testbed in Support of Validation of Functional Brain Activation


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Introduction

• Near infrared spectroscopy (NIRS) and nearinfraredophotometry (NIRx)
• Complementary sensing technologies with desirable attributes:
  - In vivo, noninvasive, and long-term measurements
  - Sensitivity to hemodynamic (NIRS) and bioelectric (NIRx) phenomena
  - Reliable at low light intensities
• BUT, experimental phantom systems, analogous to those usually utilized to evaluate structural imaging methods, currently are unavailable.
• Important for the development of functional imaging applications based on NIRS or NIRx, or both
• Used to quantitatively assess the accuracy of derivated functional information.
• Addressing this, we have taken a technology integration effort with the following goals.
  - Ability to initiate and recover complex motor behaviors (e.g., in general, are not directly observable)
  - Implement the modeled behavior in a longitudinally stable, anthropomorphic head form that supports translation from laboratory-based to subject-based studies.
• The first aim is achieved by manufacturing programmable dynamic phantoms for hemodynamic and bioelectric studies.
• Device has anthropomorphic form similar to one we reported before [1], but important aspects (a) are hierarchically encoded, (b) phantom that is stabilized against biological degradation.
• Brain components: containing group brain source element—bioelectric cells (ECC) and bioelectric dipoles—that can be precisely controlled electronically.
• Manipulation of the voltage across ECC dipoles changes its opacity, as a way of simulating a functionality of the brain.
• The dipole can be used similarly to model time-varying NIRS signals.
• The aim is accomplished by employing the same technologies, devices, headsets, and analyzer resources used in human- or animal-based studies to explore the programmable, extensible environment, or testbed.

Figs. 1-3. Two selected examples of the planned in situ mouse brain phantom. Information on the three tumors is shown in Fig. 1A, while the irradiated brain region is shown in the 3D MRI rendering of the segmented image, which were generated by the Genie phantom software. Fig. 9 shows a snapshot of the reconstructed image, highlighting the location of the tumors, which is shown as a bright solid circle. The file used in the analysis was obtained using this software. Fig. 10 shows a similar phantom with an animal brain phantom generated by the Genie phantom software. Fig. 1 shows a snapshot of the reconstructed image, highlighting the location of the tumors, which is shown as a bright solid circle. The file used in the analysis was obtained using this software.

Fig. 2. Diagram of the experiment design used to study the mouse brain phantom. Information on the three tumors is shown in Fig. 1A, while the irradiated brain region is shown in the 3D MRI rendering of the segmented image, which were generated by the Genie phantom software. Fig. 9 shows a snapshot of the reconstructed image, highlighting the location of the tumors, which is shown as a bright solid circle. The file used in the analysis was obtained using this software. Fig. 10 shows a similar phantom with an animal brain phantom generated by the Genie phantom software. Fig. 1 shows a snapshot of the reconstructed image, highlighting the location of the tumors, which is shown as a bright solid circle. The file used in the analysis was obtained using this software.

Fig. 3. Source Imaging mapping results that were systematized, as a model of the expected human brain phantom, for the purpose of the MRI and NIRS validation experiments. The image is generated using the Genie phantom software. Fig. 1 shows a snapshot of the reconstructed image, highlighting the location of the tumors, which is shown as a bright solid circle. The file used in the analysis was obtained using this software. Fig. 10 shows a similar phantom with an animal brain phantom generated by the Genie phantom software. Fig. 1 shows a snapshot of the reconstructed image, highlighting the location of the tumors, which is shown as a bright solid circle. The file used in the analysis was obtained using this software.

In vivo studies: For the in vivo studies, a 2D anatomy phantom made of neoprene or silicone rubber is used to mimic functional activation in the brain. This phantom includes regions that are made of light-absorbing materials, such as tumors or lesions, to simulate different levels of light intensity. The phantom is typically used in anesthetized animals to study the effects of light absorption and scattering on the optical properties of the brain. The phantom's design and construction are based on prior research in optical imaging techniques, and it is used in combination with various imaging modalities to study brain function.