Optical Methods for Reliable and High Fidelity Human Brain Mapping - A Hands-on course

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1155
Educational Course - Half Day (4 hours)
SEC Meeting Academy
Room: Lomond

Use of functional near infrared spectroscopy (fNIRS) and high density diffuse optical tomography (HD-DOT) technology has been growing exponentially. These diffuse optical methods for human brain mapping provide a safe, silent, and inexpensive surrogate for fMRI to map cortical brain function including in remote, under resourced, and naturalistic settings. Additionally, these diffuse optical tools have revolutionized studies on early childhood development in awake and engaged infants and toddlers in naturalistic settings and allow for direct within room dyadic interactions to be incorporated into study designs. As the number of publications in fNIRS and HD-DOT neuroimaging continues to rapidly increase, a solid foundational knowledge of different system designs and analytical approaches and their strengths and weaknesses is needed. This course will provide an extensive overview of optical system modeling and processing approaches for using near infrared diffuse optical methods for mapping brain function in humans. This course will use a combination of instructor lecturing and hands-on exercises using publicly available software with Jupyter notebooks and high-fidelity human data to teach both conceptual and practical aspects of diffuse optical imaging and spectroscopy. The desired learning outcomes include enabling the attendees to: (i) describe the fundamental principles behind diffuse light propagation in biological tissue; (ii) quantitatively evaluate system designs; (iii) evaluate inversion parameters with respect to image smoothness and resolution; (iv) quantitatively evaluate data quality with multiple metrics for optode coupling, motion contamination, and sensitivity to physiology; (v) estimate optically-measured brain responses to varying stimulus paradigms with real data; and (vi) design and construct models of source and detector arrays on a head and compare their relative sensitivity to brain function.

Objective

1) Participants will be able to evaluate and differentiate the landscape of common methods and tools used for optical neuroimaging. They should be able to read a new fNIRS and/or HD-DOT paper and critically consider its conclusions in light of the particular method's strengths and limitations, as well as other common sources of error.

2) Participants will be able to explain how to use previous neuroimaging results from both optical and fMRI studies when designing new studies. For example, they will know how to generate regions of interest when planning a

study and how to interpret novel results using common shared tools like NeuroDOT and NIRFAST.

3) Participants who participate in the hands-on tutorials will be able to perform a range of modeling and analyses using open-source tools in Python and/or tools in Matlab. Both will be presented and supported through the use of parallel Jupyter notebooks for each processing language.

Target Audience

This course will be useful for researchers and clinicians with any of these three goals:
1) To understand fNIRS and HD-DOT methods, limitations, and interpretation.
2) To quantitatively assess and track data quality and sources of spurious variance.
3) To perform optical neuroimaging analyses in a reproducible manner.

Presentations

Image reconstruction and statistical analyses

This lecture will discuss image formation and regularization as well as spatial statistical analyses. Case study 4 (25 min): Volumetric data analyses for optical brain mapping. Attendees will work with real data to explore effects of analysis parameters to map responses to retinotopy and language paradigms.

Presenter

Adam Eggebrecht, PhD, Washington University School of Medicine
Mallinckrodt Institute of Radiology
Saint Louis, MO
United States

Intro to tissue optics and system designs

This lecture will briefly discuss the physics of diffuse optics in biological tissue and common measurement system designs with a focus on functional human brain mapping. Case study 1 (25 min): Calculating sensitivity of a given system design. Attendees will explore how system design parameters including modulation frequency and source-detector layout effect sensitivity to brain function.

Presenter

Hamid Dehghani, PhD, University of Birmingham Birmingham, Birmingham
United Kingdom

Data collection and quality control

This lecture will present challenges in data collection with comparisons between various approaches for assessing data quality. Case study 2 (25 min): Assessing and visualizing data quality at multiple levels. Attendees will work with real data to explore metrics of cap coupling quality, motion, and sensitivity to physiology and brain function.

Presenter

Chiara Bulgarelli, PhD, University College London London, London
United Kingdom

Data pre-process and temporal analyses

This lecture will discuss challenges in finding the best filtering parameters and explore signal regression techniques. Case study 3 (25 min): Filters and signal regression. Attendees will again use real data to build intuition of effects of filter settings and regression techniques.

Presenter

Jason Trobaugh, PhD, Washington University in St. Louis St. Louis, MO
United States