

Introduction to Modern Brain-Computer Interface Design

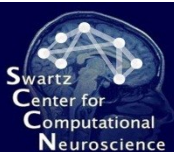
Overview

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Swartz Center for Computational Neuroscience

- Makers of open-source analysis tools:
 - EEGLAB (and plugins, e.g., MPT, NFT, AMICA)
 - BCILAB
 - SIFT
 - MoBILAB



Swartz Center for Computational

Review/edit approach

Approach properties

- Signal Processing
- Filter Ordering
- Resampling
- SamplingRate
- ChannelSelection
- Rereferencing
- ICA**
- SurfaceLaplacian
- FIRFilter
- Projection
- IIRFilter
- Standardization
- SparseReconstruction
- EpochExtraction
- TimeWindow
- EventTypes
- BaselineRemoval
- WindowSelection
- SpectralTransform
- SpectralSelection
- FrequencySpecificati
- Feature Extraction
- FeatureExtraction
- PatternPairs
- ParameterP
- ParameterQ
- SpectralPrior
- MaxIterations
- PluginFunctions
- FeatureAdaptor

ICA
Annotate the signal with a spa
ICA) (fit_ica).

dataStream Browser

Channel	Value
FPz	
FCz	
FC5	
FC6	
C3	
C4	
C2	
CP5	
CP1	
CP2	
FP7	
FP9	
FT7	
FT8	
FT9	
FT10	
FT11	
FT12	
FT13	
FT14	
FT15	
FT16	
FT17	
FT18	
FT19	
FT20	
FT21	
FT22	
FT23	
FT24	
FT25	
FT26	
FT27	
FT28	

BrainMovie3D Control Panel

Category	Parameter	Value
DataProcessing	ConnectivityMethod	nDTF
	MovieTimeRange	[-0.75 0.98828125]
	FrequenciesToCollapse	[3:7]
	FreqCollapseMethod	mean
	TimeResamplingFactor	0
	SubtractConditions	<input type="checkbox"/>
	Baseline	[]
DisplayProperties	NodeLabels	['8', '11', '13', '19', '20', '2...
	NodesToExclude	
	EdgeColorMapping	Connectivity
	EdgeSizeMapping	ConnMagnitude
NodeColorMapping	NodeColorMapping	AsymmetryRatio
	NodeSizeMapping	None
FooterPanelDisplaySpec	icaenvelopevars	
	backprojectedchans	
BrainMovieOptions	Visibility	
	RotationPath3D	
	InitialView	
	ProjectGraphOnMRI	
RenderCorticalSurface	Transparency	0.7
	UseOpenGL	on
	EventFlashTimes	[]
	DisplayLegendPanel	on
	ShowLatency	
	DisplayRTProbability	
	BackgroundColor	[0 0 0]

NodeColorMapping
Specify mapping for node color. This determines how we index into the colormap. Options are as follows. None: node color is not modulated. Outflow: sum connectivity strengths over outgoing edges. Inflow: sum connectivity strengths over incoming edges. CausalFlow: Outflow-Inflow. Asymmetry Ratio: node colors are defined by the equation $C = 0.5 * (1 + \text{outflow} - \text{inflow} / (\text{outflow} + \text{inflow}))$. This is 0 for exclusive inflow, 1 for exclusive outflow, and 0.5 for balanced inflow/outflow

Calibrate a model

Approach: lastapproach ("Spectrally Weighted C...")
Data source: lastdata ("imag.set")
Parameter Search: []
Loss/Performance Metric: Automatically chosen

Figure 2

ADHD (N=146)
AP(nogo) > AA(go)
1-7 Hz
dDTF08

connectivity

outflow

AP(nogo)-AA(go)
Back-projected ERPs. ICs > Channels

Time (sec)

1.98 sec



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- Makers of open-source analysis tools:
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- Now also makers of open-source real-time experimentation tools:
 - Lab Streaming Layer (LSL)
 - SNAP (stimulus presentation)



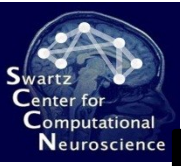
Course Prerequisites

- Linear Algebra
- Fundamentals of Programming
- Coding Experience with MATLAB



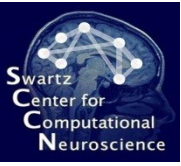
Course Overview

- Part I: Introduction to BCI Design
- Part II: The BCILAB Toolbox
- Part III: Handling Complex Brain Processes



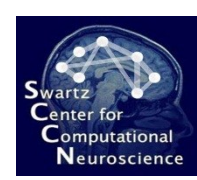
Part I: Introduction to BCI Design

- Lecture 1: Introduction
- Demo 1: The Lab Streaming Layer
- Lecture 2: EEG Basics
- Lecture 3: Signal Processing in BCIs
- Lecture 4: Adaptivity and Machine Learning
- Lecture 5: ERP Processing
- Exercise 1: Implementing ERP-based BCIs



Part II: The BCILAB Toolbox

- Lecture 6: BCILAB Toolbox Anatomy
- Demo 2: BCILAB GUI Walkthrough
- Exercise 2: ERP Analysis in BCILAB



Part III: Handling Complex Brain Processes

- Lecture 7: Oscillatory Processes
- Exercise 3: Implementing CSP-based BCIs
- Lecture 8: Optimization-based Approaches
- Lecture 9: BCILAB Scripting and Plugins
- Exercise 4: Scripting Online Analyses in BCILAB
- Exercise 5: Scripting Offline Analyses in BCILAB
- Lecture 10: Neuroscience Aspects and Outlook





Questions?