Title: **Personalized multi-scale brain simulation (virtual course)**

Responsible Person: **Prof. Dr. Petra Ritter**
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Website: https://brainsimulation.charite.de/en/
Credits: 2
Costs: free
Commercial interests: none

Learning Outcomes
After completing this module, students will know:
Basic concepts and methods for personalized brain network modeling and simulation. Students will gain theoretical knowledge and subsequently use this knowledge to construct models, process multimodal imaging data for creating individualized models, run simulations and use supporting neuroinformatics tool such as collaboratories, pipelines, workflows and data repositories. Students will be able to operate the open source neuroinformatics platform The Virtual Brain (TVB).

Content
This module provides basic knowledge on personalized brain network modeling. Required interdisciplinary methods will be introduced. A focus will be set on the open-source simulation platform The Virtual Brain (thevirtualbrain.org)

- Theoretical background of large-scale brain network modeling
- Interacting with The Virtual Brain using GUI and command line interface
- Personalization pipelines: Processing of brain images (MRI, fMRI, DTI, PET) and electrophysiological data (EEG, MEG) for individualization of brain network modeling
- Modeling resting-state networks, brain disorders, mouse, macaque, human brain activity
- Concepts of nonlinear dynamics (bifurcation analysis, phase plane, manifolds, flows on manifolds)
- Running workflows on high performance computers
- Parameter optimization and model inference
- Application of brain network modeling for clinical questions
- Visualizations of multimodal brain dynamics
- Making use of and contributing to collaborative informatics simulation platforms such as The Virtual Brain or Human Brain Project's EBRAINS
- Multiscale co-simulation using The Virtual Brain and microscopic simulators such as NEST
- Architecture of The Virtual Brain simulator

Module Components

Course name	Type	Number	Cycle	SWS
Personalized multi-scale brain simulation	VL (lecture)		WS & SS	1
Personalized multi-scale brain simulation	UE (tutorial)		WS & SS	1

Workload and Credit Points

Personalized multi-scale brain simulation – Theoretical Lecture	Multiplier	Hours	Total
Attendance	15.0	1.0	15.0h
Lecture rehearsals / individual studies	15.0	1.0	15.0h
			30.0h

Personalized multi-scale brain simulation – Hands-On Tutorial	Multiplier	Hours	Total
Attendance	15.0	1.0	15.0h
Lecture rehearsals / individual studies	15.0	1.0	15.0h
			30.0h

One ECTS/Credit Point equals 30 h workload

Description of Teaching and Learning Methods

The lecture part consists of biweekly virtual teaching using the free tool GoToMeeting (https://global.gotomeeting.com/join/286369525). In additional to the presentation of theoretical concepts, it comprises several demonstrations of how to operate workflows, simulation engines, high performance computers and collaborative platforms. Participants are expected to rehearse content after class, using their class notes, digital jupyter notebooks, video tutorials and recommended literature, in preparation for the exercises and tutorials. Homework assignments are given biweekly and must be solved between two weeks. These assignments cover the different methods of the course and comprise setting up simulations, operating workflows or modifying existing code to address specific scientific problems. Working in small teams of ca. 3 individuals is encouraged. Homework assignments and their solutions are discussed during the hands-on tutorials. In the hand-on tutorials we address specific problems and are solving them together. This requires operating simulation software and informatics tools.

Requirements for Participation and Examination

Desirable prerequisites: Basic programming skills in Python
Mandatory requirements: Good English language skills, Basic programming expertise

Module Completion
Type of exam: oral exam
Grading: graded

Duration of the Module
This module can be completed in 1 semester

Maximum Number of Participants
50

Registration Procedures
Registration via email is required: petra.ritter@charite.de
Enrollment to the module is handled in the first class of each module component. Students must be present at the virtual meeting.

Recommended Reading

1. Poldrack, Feingold, Frank, Gleeson, de Hollander, Huys, Love, Markiewitcz, Moran, Ritter, Turner, Yarkoni, Zhang, Cohen. (2019) The importance of standards for sharing of computational models and data. Computational Brain & Behavior
2. Shen K, Bezgin G, Schirner M, Ritter P, Everling S, McIntosh AR (2019) A macaque connectome for large-scale network simulations in TheVirtualBrain Nature Scientific Data
3. Leon Stefanovski, Paul Triebkorn, Andreas Spiegler, Margarita-Arimatea Diaz-Cortes, Ana Solodkin, Viktor Jirsa, Anthony Randal McIntosh, Petra Ritter; for the Alzheimer's Disease Neuroimaging Initiative (2019). Linking molecular pathways and large-scale computational modeling to assess candidate disease mechanisms and pharmacodynamics in Alzheimer's disease. Frontiers Computational Neuroscience
4. Schirner, McIntosh, Jirsa, Deco, Ritter (2018) Inferring multi-scale neural mechanisms with brain network modelling. eLife
5. Deco, Kringelbach, Jirsa, Ritter (2017) The dynamics of resting fluctuations in the brain: metastability and its dynamical core. Scientific Reports
6. Kringelbach, McIntosh, Ritter, Jirsa, Deco (2015) The rediscovery of slowness: exploring the timing of cognition. Trends in Cognitive Science 19(10):616-28
7. Schirner, M., S. Rothmeier, V. Jirsa, A. R. McIntosh and Ritter, P. (2015). An automated pipeline for constructing personalised virtual brains from multimodal neuroimaging data. Neuroimage

Lecture Notes
https://training.incf.org/collection/virtual-brain-simulation-platform
Lecture notes will be available in several cases in form of jupyter notebooks that are accessible and executable via a joint workspace – the EBRAINS Collaboratory of the Human Brain Project: ebrains.eu

Assigned Degree Programs
Students of other courses can take this module if capacity allows

Miscellaneous
Open-source Software The Virtual Brain (thevirtualbrain.org) can be installed on own notebook/computer (runs on MacOS, Linux, Windows), used via EBRAINS (requires free registration at ebrains.eu)

Course structure:
The course takes place in the summer and winter semester and consists of the following parts:
Lectures: 1 ECTS
Hands-on tutorials: 1 ECTS
Dates WS 2020/21:
December 1, 2020 – March 31,2021

Thursdays
Dec 3rd 15-16:30 = 2 units á 45 min
Dec 17th 15-18:10 = 4 units á 45 min
Jan 7th 15-18:10 = 4 units á 45 min
Jan 21st 15-18:10 = 4 units á 45 min
Feb 4th 15-18:10 = 4 units á 45 min
Feb 18th 15-18:10 = 4 units á 45 min
Breaks from 16:30-16:40
Total: 30h

Target group:
Master and PhD students with interest in the topic

Course certificates:
Students have to solve homework assignments which are given at the course and must be solved before the next course, that is in two weeks. After the course an oral exam takes place. The certificate of successful participation in the tutorial is a prerequisite for the oral exam. Students who successfully pass the oral exam are awarded 2 ECTS.

Trainings-Typ: Webinar
Anbieter: Brain Simulation Section
ECTS: 2
Location: https://global.gotomeeting.com/join/286369525
Registration: petra.ritter@charite.de