Virtual Course Series – Fall 2023

The Virtual Brain in Clinical Research: An Introduction

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Online information:

- Official website
- BCCN Elective Courses
- Charité Promotionskurse

Type of Course

Training type: Webinar
Language: English
Location: Online
Commercial interests: None
Costs: Free
Credit Course:

- Level: M.Sc., 2 ECTS (Bernstein Center Computational Neuroscience Berlin (BCCN))
- Level: Ph.D., 3 ECTS (Charité Promotionsumgebung)

REGISTRATION HERE

Learning Outcomes

After completing this module, participants will know the basic concepts and methods for personalized brain network modeling and simulation. Students will gain knowledge about how to construct brain models, process multimodal imaging data for creating individualized brain models, run simulations and use supporting neuroinformatics tool such as the Charité/BIH Virtual Research Environment and workflows.
Students will understand how to model and simulate brain network model to address medical questions and have a good understanding of the open-source neuroinformatics platform The Virtual Brain (TVB; thevirtualbrain.org).

Content

This module provides basic knowledge on personalized brain network modeling for state-of-the-art in clinical research. Required interdisciplinary methods will be introduced. A focus will be set on the open-source simulation platform TVB.

Course overview:

- Theoretical background of large-scale brain network modeling
- Personalization pipelines: processing of brain images for individualization of brain network modeling
- Concepts of nonlinear dynamics
- Running workflows on high-performance computers
- Parameter optimization and model inference
- Application of brain network modeling for clinical questions
- Introduction to the medical condition targeted through brain simulation: dementias, psychosis
- Visualizations of multimodal brain dynamics, ontologies, machine learning, graph theory
- Making use of digital Research Infrastructures used for data integration and simulation in compliance with the EU general Data Protection Regulations (GDPR)

Modules Components

Course name	Type	Number	Cycle	SWS
The Virtual Brain in Clinical Research: An Introduction	VL (lecture)	1	SS & WS	1

Workload and Credit Points

The Virtual Brain in Clinical Research: An Introduction	Multiplier	Units	Total Units
Attendance	12	2.5	30
Lecture rehearsals / individual studies	12	2.5	30
			60

1unit = 45 min

One ECTS/Credit Point equals 30 units (for Master students at the Bernstein Center Computational Neuroscience Berlin, BCCN)/ 20 units (for PhD students at the Charité Promotionsumgebung).

2 ECTS for Master students at the Bernstein Center Computational Neuroscience Berlin (BCCN), and 3 ECTS for PhD students at the Charité Promotionsumgebung.

Description of teaching and learning methods
The lecture part consists of weekly virtual teaching using the conference platform GoToMeeting. In addition to the presentation of theoretical concepts, the course 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.

Requirements for Participation and Examination
Mandatory requirements:
- Good English language skills
- Basic programming expertise (Python, Matlab)

Successful module completion will require participation in a written exam. Exam tasks will be provided during the last course week and results need to be submitted by until one week after.

Module Completion
Type of exam: written exam
Grading: none

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

Maximum Number of Participants
50

Registration Procedure
Registration is FREE but mandatory via the following online form.

Access online course
A join link is sent to the participants before each session to join the virtual online meeting space.

Recommended Reading

- Schirner et al. (2023) Learning how network structure shapes decision-making for bio-inspired computing. *Nat. Commun.*
- Schirner et al. (2022). Brain Simulation as a Cloud Service: The Virtual Brain on EBRAINS. *NeuroImage*
- Meier et al. (2022). Virtual deep brain stimulation: Multiscale co-simulation of spiking basal ganglia model and whole-brain mean-field model with The Virtual Brain. *Exp. Neurol.*
- Schirner et al. (2022). Dynamic primitives of brain network interaction. *NeuroImage*
- Triebkorn et al.(2022). Alzheimer's Disease Neuroimaging Initaitive. Brain Simulation augments machine-learning-based classification of dementia. *Alzheimer's Dement.*

- Stefanovski et al. (2021). Bridging Scales in Alzheimer's disease: Biological framework for brain simulation with The Virtual Brain. *Front. Neuroinform.*
- Stefanovski et al. (2019). Linking molecular pathways and large-scale computational modeling to assess candidate disease mechanisms and pharmacodynamics in Alzheimer's disease. *Front. Comput. Neurosci.*
- Schirner et al. (2018). Inferring multi-scale neural mechanisms with brain network modelling. *eLife*
- Deco et al. (2017). The dynamics of resting fluctuations in the brain: metastability and its dynamical core. *Sci. Rep.*
- Schirner et al. (2015). An automated pipeline for constructing personalised virtual brains from multimodal neuroimaging data. *NeuroImage*
- Ritter et al. (2013). The virtual brain integrates computational modeling and multimodal neuroimaging. *Brain Connectivity*

Lecture Notes

Lecture presentations will be made available and published here:

- TVB - INCF Training Space
- TVB – YouTube Channel

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) or used via the research infrastructure EBRAINS (requires free registration at https://www.ebrains.eu/page/sign-up).

Course Structure

The courses take place in the summer and winter semester and consists of the following parts: Lectures and self-study.

Dates SS/WS 2023:
September 5, 2023 – November 28,2023

Every Tuesday

1. Sep 5 16:30-18:30 = 2.5 units á 45 min
2. Sep 12 16:30-18:30 = 2.5 units á 45 min
3. Sep 19 16:30-18:30 = 2.5 units á 45 min
4. Sep 26 16:30-18:30 = 2.5 units á 45 min
5. Oct 10 16:30-18:30 = 2.5 units á 45 min
6. Oct 17 16:30-18:30 = 2.5 units á 45 min
7. Oct 24 16:30-18:30 = 2.5 units á 45 min

8. Oct 31 16:30-18:30 = 2.5 units á 45 min
9. Nov 7 16:30-18:30 = 2.5 units á 45 min
10. Nov 14 16:30-18:30 = 2.5 units á 45 min
11. Nov 21 16:30-18:30 = 2.5 units á 45 min
12. Nov 28 16:30-18:30 = 2.5 units á 45 min

Total: 30 units á 45 min
Each session has a short bio break of 7 minutes.

Target Group
Master and PhD students with interest in the topic of computational neuroscience and its applications in clinical research.

Course Certificate
Students have to pass a written exam that can be completed at home. The exam tasks are given in the last week of the course and must be solved until one week later. Students who successfully pass the written exam are awarded 2 or 3 ECTS depending on their program enrollment.

Program

Week 1 "**The Virtual Brain - Overview**" – Prof. Dr. Petra Ritter

Recommendation for self-study:
- Schirner et al. (2023). Learning how network structure shapes decision-making for bio-inspired computing. *Nat. Commun.*
- Schirner et al. (2022). Brain Simulation as a Cloud Service: The Virtual Brain on EBRAINS. *NeuroImage*

Week 2 **"Introduction to The Virtual Brain"** – Dr. Julie Courtiol

Recommendation for self-study:
- Sanz-Leon et al. (2015). Mathematical framework for large-scale brain network modeling in The Virtual Brain. *NeuroImage*
- Schirner et al. (2022). Dynamic primitives of brain network interaction. *NeuroImage*
- Schirner et al. (2018). Inferring multi-scale neural mechanisms with brain network modelling. *eLife*

Week 3 **"Modeling neurodegeneration"** – Dr. Leon Stefanovski

Recommendation for self-study:

- Stefanovski et al. (2019). Linking molecular pathways and large-scale computational modeling to assess candidate disease mechanisms and pharmacodynamics in Alzheimer's disease. *Front. Comput. Neurosci.*
- Triebkorn et al. (2022). Alzheimer's Disease Neuroimaging Initaitive. Brain Simulation augments machine-learning-based classification of dementia. *Alzheimer's Dement.*

Week 4 "Integrating biological knowledge in brain network models" – Leon Martin, M.Sc.

Recommendation for self-study:

- TVBase description video
- Ontologies - Virtual Course 2021
- Stefanovski et al. (2021). Bridging Scales in Alzheimer's disease: Biological framework for brain simulation with The Virtual Brain. *Front. Neuroinform.*

Week 5 "**Combining AI and Brain Modeling**" – Dr. Kiret Dhindsa

Recommendation for self-study:

- Triebkorn et al. (2022). Alzheimer's Disease Neuroimaging Initaitive. Brain Simulation augments machine-learning-based classification of dementia. *Alzheimer's Dement.*

Week 6 "**The Virtual Brain and multiscale co-simulation**" – Dr. Dionysios Perdikis

Recommendation for self-study:

- Schirner et al. (2022). Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS. *NeuroImage*
- Sanz-Leon et al. (2015). Mathematical framework for large-scale brain network modeling in The Virtual Brain. *NeuroImage*

Week 7 "**Generating virtual brains using tailored brain image processing workflows**" – Patrik Bey, M.Sc.

Recommendation for self-study:

- Virtual Research Environment – Virtual Course 2021
- Schirner et al. (2022). Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS. *NeuroImage*
- Schirner et al. (2015). An automated pipeline for constructing personalised virtual brains from multimodal neuroimaging data. *NeuroImage*

Week 8 "**In silico optimization of deep brain stimulation**" – Dr. Jil Meier

Recommendation for self-study:

- Meier et al. (2022). Virtual deep brain stimulation: Multiscale co-simulation of spiking basal ganglia model and whole-brain mean-field model with The Virtual Brain. *Exp. Neurol.*

Week 9 "**TVB-Positron Emission Tomography**" – Dr. Halgurd Taher

Recommendation for self-study:

- Ritter et al. (2013). The virtual brain integrates computational modeling and multimodal neuroimaging. *Brain Connectivity*

Week 10 "**Understanding principles of traveling waves**" – Dominik Koller, M.Sc.

Recommendation for self-study:

- Muller et al. (2016). Rotating waves during human sleep spindles organize global patterns of activity that repeat precisely through the night. *eLife*

Week 11 **"Workflows on GDPR compliant platforms: Virtual Research Environment and Health Data Cloud**" – Dr. Michael Schirner

Recommendation for self-study:

- Schirner et al. (2022). Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS. *NeuroImage*

Week 12 "**Modeling mechanisms of psychosis**" – Dr. Konstantin Bülau

Recommendation for self-study:

- Costa Klein et al. (2020). Brain Network Simulations Indicate Effects of Neuregulin-1 Genotype on Excitation-Inhibition Balance in Cortical Dynamics. *Cerebral Cortex*
- Domingo-Fernández et al. (2017). Multimodal mechanistic signatures for neurodegenerative diseases (NeuroMMSig): a web server for mechanism enrichment. *Bioinformatics*