Online Summer School

The Virtual Brain in Clinical Research

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Official website: https://www.brainsimulation.org/bsw/zwei/events/single/9651-online-summer-school-the-virtual-brain-in-clinical-research
BCCN website: https://www.bccn-berlin.de/courses-and-modules.html
Charité website:
https://intranet.charite.de/studium_lehre/promotionskurse/kurs/promotionskurse_detail/the_virtual_brain_in_clinical_research_an_introduction/

Training type: Webinar
Language: English
Location: Online
Costs: Free
Commercial interests: None
Registration: Online form
https://docs.google.com/forms/d/e/1FAIpQLSdUb69L16sVn3eIyruuK2-VoXV9Zg2eu6Nt3QTKVDNcAyy87g/viewform
Credits: 2 ECTS for Master students at the Bernstein Center Computational Neuroscience Berlin (BCCN), and 3 ECTS for PhD students at the Charité (Promotionsumgebung)

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 models, process multimodal imaging data for creating individualized models, run simulations and use supporting neuroinformatics tool such as the Charité/BIH Virtual Research Environment, workflows and build interfaces to related tools via APIs. Students will understand how to run brain simulations to address medical problems 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
- Introduction to the medical condition targeted through brain simulation: dementias and 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)

Module Components

Course name	Type	Number	Cycle	SWS
The Virtual Brain in Clinical Research	VL (lecture)	1	SS	1

Workload and Credit Points

The Virtual Brain in Clinical Research	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 BCCN and 20 units for PhD students at the Charité.

2 ECTS for Master students at the BCCN, and 3 ECTS for PhD students at the Charité.

Description of Teaching and Learning Methods

The lecture part consists of weekly virtual teaching using the free conference platform GoToMeeting. In addition 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.

Requirements for Participation and Examination
Mandatory requirements:

- Good English language skills
- Basic programming expertise

Successful module completion will require participation in a written exam.

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 via online form is required:
https://docs.google.com/forms/d/e/1FAIpQLSdUb69L16sVn3eIyruuK2-VoXV9Zg2eu6Nt3QTKVDNcAyy87g/viewform

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

Recommended Reading

- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter (2022). Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS. Neuroimage
- Meier, Perdikis, Blickensdörfer, Stefanovski, Liu, Maith, Dinkelbach, Baladron, Hamker, Ritter (2022). Virtual deep brain stimulation: Multiscale co-simulation of spiking basal ganglia model and whole-brain mean-field model with The Virtual Brain. Experimental Neurology
- Schirner, Kong, Yeo, Deco, Ritter (2022). Dynamic primitives of brain network interaction. Neuroimage
- Triebkorn, Stefanovski, Dhindsa, Diaz-Cortes, Bey, Bülau, Pai, Spiegler, Jirsa, McIntosh, Ritter (2022). Alzheimer's Disease Neuroimaging Initaitive. Brain Simulation augments machine-learning-based classification of dementia. Alzheimer's and Dementia Translational Research & Clinical Interventions

- Stefanovski, Meier, Pai, Triebkorn, Lett, Martin, Bülau, Hofmann-Apitius, Solodkin, McIntosh, Ritter (2021). Bridging Scales in Alzheimer's disease: Biological framework for brain simulation with The Virtual Brain. Frontiers in Neuroinformatics
- Stefanovski, Triebkorn, Spiegler, Diaz-Cortes, Solodkin, Jirsa, McIntosh, 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
- Schirner, McIntosh, Jirsa, Deco, Ritter (2018). Inferring multi-scale neural mechanisms with brain network modelling. eLife
- Deco, Kringelbach, Jirsa, Ritter (2017). The dynamics of resting fluctuations in the brain: metastability and its dynamical core. Scientific Reports
- 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
- Ritter, P., M. Schirner, A. R. McIntosh and V. K. Jirsa (2013). The virtual brain integrates computational modeling and multimodal neuroimaging. Brain Connect

Lecture Notes

Lecture notes will be made available for all classes. Presentations will be published here:

INCF Training Space: https://training.incf.org/collection/virtual-brain-simulation-platform
YouTube: https://www.youtube.com/channel/UCZxHt1mmrCafBwS4iPoUSrQ/playlists

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://ebrains.eu/register/).

Course Structure

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

Dates SS 2022:
June 28, 2022 – September 13, 2022

Every Tuesday

1. June 28th 16:30-18:30 = 2.5 units á 45 min
2. July 5th 16:30-18:30 = 2.5 units á 45 min
3. July 12th 16:30-18:30 = 2.5 units á 45 min
4. July 19th 16:30-18:30 = 2.5 units á 45 min

5.	July 26th	18:30-20:30 = 2.5 units á 45 min *(starts 2h later than usual!)*
6.	August 2nd	16:30-18:30 = 2.5 units á 45 min
7.	August 9th	16:30-18:30 = 2.5 units á 45 min
8.	August 16th	16:30-18:30 = 2.5 units á 45 min
9.	August 23rd	16:30-18:30 = 2.5 units á 45 min
10.	August 30th	16:30-18:30 = 2.5 units á 45 min
11.	September 6th	16:30-18:30 = 2.5 units á 45 min
12.	September 13th	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:
- Deco, Kringelbach, Jirsa, Ritter (2017). The dynamics of resting fluctuations in the brain: metastability and its dynamical core. Scientific Reports
- Ritter, P., M. Schirner, A. R. McIntosh and V. K. Jirsa (2013). The virtual brain integrates computational modeling and multimodal neuroimaging. Brain Connect

Week 2 "Inferring mechanisms through brain network modeling" – Dr. Michael Schirner

Recommendation for self-study:
- Schirner, Kong, Yeo, Deco, Ritter (2022). Dynamic primitives of brain network interaction. Neuroimage
- Schirner, McIntosh, Jirsa, Deco, Ritter (2018). Inferring multi-scale neural mechanisms with brain network modelling. eLife

Week 3 "Modeling neurodegeneration" – Dr. Leon Stefanovski

Recommendation for self-study:

- Stefanovski, Triebkorn, Spiegler, Diaz-Cortes, Solodkin, Jirsa, McIntosh, 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
- Triebkorn, Stefanovski, Dhindsa, Diaz-Cortes, Bey, Bülau, Pai, Spiegler, Jirsa, McIntosh, Ritter (2022). Alzheimer's Disease Neuroimaging Initaitive. Brain Simulation augments machine-learning-based classification of dementia. Alzheimer's and Dementia Translational Research & Clinical Interventions

Week 4 **"Integrating biological knowledge in brain network models"** – Leon Martin

Recommendation for self-study:

- https://www.youtube.com/watch?v=QzEyD-9HOw8&t=5s
- Stefanovski, Meier, Pai, Triebkorn, Lett, Martin, Bülau, Hofmann-Apitius, Solodkin, McIntosh, Ritter (2021). Bridging Scales in Alzheimer's disease: Biological framework for brain simulation with The Virtual Brain. Frontiers in Neuroinformatics

Week 5 "**Modeling mechanisms of psychosis**" – Dr. Konstantin Bülau

Recommendation for self-study:

- Costa Klein, Ettinger, Schirner, Ritter, Rujescu, Falkai, Koutsouleris, Kambeitz-Ilankovic, Kambeitz (2020) Brain Network Simulations Indicate Effects of Neuregulin-1 Genotype on Excitation-Inhibition Balance in Cortical Dynamics. Cerebral Cortex
- Domingo-Fernández, D., Kodamullil, A. T., Iyappan, A., Naz, M., Emon, M. A., Raschka, T., . . . Hofmann-Apitius, M. (2017). Multimodal mechanistic signatures for neurodegenerative diseases (NeuroMMSig): a web server for mechanism enrichment. Bioinformatics

Week 6 "**Machine learning basics**" – Dr. Kiret Dhindsa

Recommendation for self-study:

- Triebkorn, Stefanovski, Dhindsa, Diaz-Cortes, Bey, Bülau, Pai, Spiegler, Jirsa, McIntosh, Ritter (2022). Alzheimer's Disease Neuroimaging Initaitive. Brain Simulation augments machine-learning-based classification of dementia. Alzheimer's and Dementia Translational Research & Clinical Interventions

Week 7 "**The Virtual Brain and multiscale co-simulation**" – Dr. Dionysios Perdikis

Recommendation for self-study:

- TVB advanced tutorials https://training.incf.org/course/virtual-brain-node-6-workshop
- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch,

Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter (2022). Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS. Neuroimage
- Sanz-Leon, P., Knock, S. A., Spiegler, A., & Jirsa, V. K. (2015). Mathematical framework for large-scale brain network modeling in The Virtual Brain. Neuroimage

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

Recommendation for self-study:
- Meier, Perdikis, Blickensdörfer, Stefanovski, Liu, Maith, Dinkelbach, Baladron, Hamker, Ritter (2022). Virtual deep brain stimulation: Multiscale co-simulation of spiking basal ganglia model and whole-brain mean-field model with The Virtual Brain. Experimental Neurology

Week 9 "**Workflows on GDPR compliant platforms: VRE and EBRAINS**" – Dr. Michael Schirner

Recommendation for self-study:
- Schirner, Domide, Perdikis, Triebkorn, Stefanovski, Pai, Prodan, Valean, Palmer, Langford, Blickensdörfer, van der Vlag, Diaz-Pier, Peyser, Woodman, Zehl, Fousek, Petkoski, Kusch, Hashemi, Marinazzo, Mangin, Flöel, Akintoye, Stahl, Deco, McIntosh, Hilgetag, Morgan, Schuller, Upton, McMurtrie, Dickscheid, Bjaalie, Amunts, Mersmann, Jirsa, Ritter (2022). Brain Simulation as a Cloud Service: The Virtual Brain on the European Research Platform EBRAINS. Neuroimage
- 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

Week 10 "**The Virtual Brain Ontology**" – Dr. Julie Courtiol

Recommendation for self-study:
- Sanz-Leon, P., Knock, S. A., Spiegler, A., & Jirsa, V. K. (2015). Mathematical framework for large-scale brain network modeling in The Virtual Brain. Neuroimage
- Stefanovski, Triebkorn, Spiegler, Diaz-Cortes, Solodkin, Jirsa, McIntosh, 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
- https://www.youtube.com/watch?v=UyS7Tt3oVuE

Week 11 "**Generating stroke virtual brains using docker images**" – Patrik Bey

Recommendation for self-study:
- https://www.youtube.com/watch?v=vFsi7L9zPdk&t=8s

Week 12 "**Understanding principles of traveling waves**" – Dominik Koller

Recommendation for self-study:

- Muller, Piantoni, Koller, Cash, Halgren, Sejnowski (2016). Rotating waves during human sleep spindles organize global patterns of activity that repeat precisely through the night. elife