Virtual Fall School

The Virtual Brain in Clinical Research: An Introduction

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Official website: https://www.brainsimulation.org/bsw/zwei/events/single/7420-the-virtual-brain-in-clinical-research-an-introduction
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
Cost: Free
Commercial interests: None
Registration: Online form here
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
- Application of brain network modeling for clinical questions
- Introduction to the medical condition targeted through brain simulation: dementias, psychosis and epilepsy
- 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: An Introduction	VL (lecture)	1	WS & SS	1

Workload and Credit Points

The Virtual Brain in Clinical Research: An Introduction	Multiplier	Hours	Total
Attendance	30	1	30h
Lecture rehearsals / individual studies	30	1	30h
			60h

One ECTS/Credit Point equals 30 h workload.

Description of Teaching and Learning Methods

The lecture part consists of weekly virtual teaching using the free tool *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

Module Completion
Type of exam: written exam
Grading: none
Successful module completion will require participation in a written exam. Exam tasks will be provided in week 14 (Jan 25th) and results need to be submitted by February 8th, 2022.

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/1FAIpQLSdwQSYwpKcb07e_PLM1CK1zlcGi7uTwmUrk7QN0D5VcgSjM_A/viewform

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*. doi: 10.1007/s42113-019-00062-x
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*. doi: 10.1038/s41597-019-0129-z
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*. doi: 10.3389/fncom.2019.00054
4. Schirner, McIntosh, Jirsa, Deco, Ritter (2018) Inferring multi-scale neural mechanisms with brain network modelling. eLife doi: 10.7554/eLife.28927
5. Deco, Kringelbach, Jirsa, Ritter (2017) The dynamics of resting fluctuations in the brain: metastability and its dynamical core. *Scientific Reports*. doi: 10.1038/s41598-017-03073-5
6. Kringelbach, McIntosh, Ritter, Jirsa, Deco (2015) The rediscovery of slowness: exploring the timing of cognition. *Trends in Cognitive Science* 19(10):616-28. doi: 10.1016/j.tics.2015.07.011
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*. doi: 10.1016/j.neuroimage.2015.03.055

8. Ritter, P., M. Schirner, A. R. McIntosh and V. K. Jirsa (2013). The virtual brain integrates computational modeling and multimodal neuroimaging. *Brain Connect* 3(2): 121-145 doi: 10.1089/brain.2012.0120

Lecture Notes
Lecture notes will be made available for all classes:

- Brain Modes Youtube Channel
- INCF Training Space - TVB *(soon)*

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 ebrains.eu).

Course Structure
The courses take place in the summer and winter semester and consists of the following parts:
Lectures and self-study: 2 or 3 ECTS depending on the program enrollment
Dates WS 2021/22:
Oct 5, 2021 – Feb 1,2022

Tuesday	
Oct 5	18-19:30 = 2 units á 45 min
Oct 12	18-19:30 = 2 units á 45 min
Oct 19	18-19:30 = 2 units á 45 min
Oct 26	18-19:30 = 2 units á 45 min
Nov 2	18-19:30 = 2 units á 45 min
Nov 9	18-19:30 = 2 units á 45 min
Nov 16	18-19:30 = 2 units á 45 min
Nov 23	18-19:30 = 2 units á 45 min
Nov 30	18-19:30 = 2 units á 45 min
Dec 7	18-19:30 = 2 units á 45 min
Dec 14	18-19:30 = 2 units á 45 min
Jan 11	18-19:30 = 2 units á 45 min
Jan 18	18-19:30 = 2 units á 45 min
Jan 25	18-19:30 = 2 units á 45 min
Feb 1	18-19:30 = 2 units á 45 min

Total: 30 units á 45 min

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 week 14 (Jan 25th) of the course and must be solved by Feb 8th, 2022, that is in two weeks. Students who successfully pass the written exam are awarded 2 or 3 ECTS depending on their program enrollment.

Weekly talks, regularly on Tuesday at 6 p.m.
Weekly background recommendations and practical homework

Program
Week 1 – October 5th

Talk at 6 p.m.:
- "**The Virtual Brain - Overview**" by Prof. Dr. Petra Ritter

Recommendation for self-study:
- Read **Schirner et al. 2018**
  - Schirner, McIntosh, Jirsa, Deco, Ritter (2018) Inferring multi-scale neural mechanisms with brain network modelling. *eLife* doi: 10.7554/eLife.28927
- Read **Ritter et al. 2013**
  - Ritter, P., M. Schirner, A. R. McIntosh and V. K. Jirsa (2013). The virtual brain integrates computational modeling and multimodal neuroimaging. *Brain Connect* 3(2): 121-145 doi: 10.1089/brain.2012.0120

Week 2 – October 12th

Talk at 6 p.m.:
- "**Ontologies and their importance for brain modeling**" by Dr. Konstantin Bülau

Recommendation for self-study:
- Read **Berners-Lee et al. 2001**
  - Berners-Lee, T. I. M., Hendler, J., & Lassila, O. R. A. (2001). THE SEMANTIC WEB. *Scientific American, 284*(5), 34-43. Retrieved from www.jstor.org/stable/26059207
- Read **Domingo-Fernández et al. 2017**
  - 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, 33*(22), 3679-3681. doi: 10.1093/bioinformatics/btx399

Week 3 – October 19th

Talk at 6 p.m.:

- "**Dementias in the context of brain simulation**" by Dr. Leon Stefanovski

Recommendation for self-study:

- Read **Jack et al. 2018**
  - Jack, C. R., Jr., Bennett, D. A., Blennow, K., Carrillo, M. C., Dunn, B., Haeberlein, S. B., . . . Silverberg, N. (2018). NIA-AA Research Framework: Toward a biological definition of Alzheimer's disease. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association, 14*(4), 535-562. doi: 10.1016/j.jalz.2018.02.018

Week 4 – October 26th

Talk at 18 p.m.:

- "**Psychosis - linking clinical practice and theory**" by Leon Martin

Recommendation for self-study:

- TVB Introduction videos
  - https://training.incf.org/lesson/improving-life-through-simulation

Week 5 - November 2nd

Talk at 6 p.m.:

- "**Fundamentals of The Virtual Brain**" by Dr. Dionysios Perdikis

Recommendation for self-study:

- TVB advanced tutorials
  - https://training.incf.org/course/virtual-brain-node-6-workshop

Week 6 - November 9th

Talk at 6 p.m.:

- "**The virtual epileptic patient**" by Dr. Julie Courtiol

Recommendation for self-study:

- Read **Sanz-Leon et al. 2015**
  - 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, 111*, 385-430. doi: 10.1016/j.neuroimage.2015.01.002
- Read **Jirsa et al. 2017**

  Jirsa, V. K., Proix, T., Perdikis, D., Woodman, M. M., Wang, H., Gonzalez-Martinez, J., . . . Bartolomei, F. (2017). The Virtual Epileptic Patient: Individualized whole-

brain models of epilepsy spread. *Neuroimage, 145*(Pt B), 377-388. doi: 10.1016/j.neuroimage.2016.04.049

Week 7 – November 16th

Talk at 6 p.m.:

- "**Basics TVB Programming – GUI, iPython & MATLAB**" by Dr. Leon Stefanovski

Recommendation for self-study:

- Read **Stefanovski et al. 2019**
  - Stefanovski, L., Triebkorn, P., Spiegler, A., Diaz-Cortes, M. A., Solodkin, A., Jirsa, V., . . . Ritter, P. (2019). Linking Molecular Pathways and Large-Scale Computational Modeling to Assess Candidate Disease Mechanisms and Pharmacodynamics in Alzheimer's Disease. *Frontiers in Computational Neuroscience*. doi: 10.3389/fncom.2019.00054

Week 8 – November 23rd

Talk at 6 p.m.:

- "**Machine learning basics**" by Dr. Kiret Dhindsa

Recommendation for self-study:

- Read **Triebkorn et al. 2021**
  - Triebkorn, P., Stefanovski, L., Dhindsa, K., Diaz-Cortes, M.-A., Bey, P., Bülau, K., . . . Ritter, P. (2021). Multi-scale brain simulation with integrated positron emission tomography yields hidden local field potential activity that augments machine learning classification of Alzheimer's disease. *bioRxiv*, 2021.2002.2027.433161. doi: 10.1101/2021.02.27.433161

Week 9 – November 30th

Talk at 6 p.m.:

- "**Graph theory**" by Dr. Jil Meier

Recommendation for self-study:

- Read **Triebkorn et al. 2021**
  - Triebkorn, P., Zimmermann, J., Stefanovski, L., Roy, D., Solodkin, A., Jirsa, V., . . . Ritter, P. (2020). Identifying optimal working points of individual Virtual Brains: A large-scale brain network modelling study. *bioRxiv*, 2020.2003.2026.009795. doi: 10.1101/2020.03.26.009795

Week 10 – December 7th

Talk at 6 p.m.:
- "**The Virtual Research Environment**" by Paul Pawletta

Recommendation for self-study:
- Read **Schirner et al. 2021**
  - Schirner, M., Domide, L., Perdikis, D., Triebkorn, P., Stefanovski, L., Pai, R., . . . Langford, C. (2021). Brain Modelling as a Service: The Virtual Brain on EBRAINS. *arXiv: 2102.05888*

Week 11 – December 14th

Talk at 6 p.m.:
- "**MRI processing basics**" by Leon Martin

Recommendation for self-study:
- Read **Fischl et al. 2016**
  - Fischl, B., Salat, D. H., Busa, E., Albert, M., Dieterich, M., Haselgrove, C., . . . Dale, A. M. (2002). Whole brain segmentation: automated labeling of neuroanatomical structures in the human brain. *Neuron, 33*(3), 341-355. doi: 10.1016/s0896-6273(02)00569-x

Week 12 - January 11th

Talk at 6 p.m.:
- "**The HCP parcellation standards**" by Leon Martin

Recommendation for self-study:
- Read **Glasser et al. 2013**
  - Glasser, M. F., Sotiropoulos, S. N., Wilson, J. A., Coalson, T. S., Fischl, B., Andersson, J. L., . . . Consortium, W. U.-M. H. (2013). The minimal preprocessing pipelines for the Human Connectome Project. *Neuroimage, 80*, 105-124. doi: 10.1016/j.neuroimage.2013.04.127

Week 13 - January 18th

Talk at 6 p.m.:
- "**Fundamentals of human neuroanatomy**" by Leon Martin, Dr. Leon Stefanovski, Dr. Konstantin Bülau

Recommendation for self-study:
- Read **Amunts et al. 2020**

  - Amunts, K., Mohlberg, H., Bludau, S., & Zilles, K. (2020). Julich-Brain: A 3D probabilistic atlas of the human brain's cytoarchitecture. *Science, 369*(6506), 988-992. doi: 10.1126/science.abb4588
- Read **Dockès et al. 2020**
  - Dockès, J., Poldrack, R. A., Primet, R., Gözükan, H., Yarkoni, T., Suchanek, F., . . . Varoquaux, G. (2020). NeuroQuery, comprehensive meta-analysis of human brain mapping. *eLife, 9*, e53385. doi: 10.7554/eLife.53385

Week 14 - January 25th

Talk at 6 p.m.:
- "**MRI processing for The Virtual Brain**" by Dr. Michael Schirner

Recommendation for self-study:
- Read **Glasser et al. 2016**
  - Glasser, M. F., Coalson, T. S., Robinson, E. C., Hacker, C. D., Harwell, J., Yacoub, E., . . . Van Essen, D. C. (2016). A multi-modal parcellation of human cerebral cortex. *Nature, 536*(7615), 171-178. doi: 10.1038/nature18933

Week 15 – February 1st

Talk at 6 p.m.:
- "**APIs – Interfacing tools and services**" by Dr. Konstantin Bülau

Recommendation for self-study:
- Read **Dörpinghaus et al. 2020**
  - Dörpinghaus, J., Klein, J., Darms, J., Madan, S., & Jacobs, M. (2018). *SCAIView-A Semantic Search Engine for Biomedical Research Utilizing a Microservice Architecture.* Paper presented at the SEMANTiCS 2018 Posters&Demos.