CNS*2023 Leipzig

TYPE - WORKSHOP • JULY 18 • TUESDAY

W Workshop

JULY 18 • TUESDAY

09:00 – 12:30 W **W01: Computational modeling of transcranial magnetic stimulation** Goethe

Speakers: Shih-Cheng Chien, Helmut Schmidt, Thomas R. Knösche, Konstantin Weise, Aaron Miller, Torge Worbs, Vincenzo Di Lazzaro, Laura Marzetti

Organizers:

Konstantin Weise, MPI for Human Cognitive and Brain Sciences
Thomas R. Knösche, MPI for Human Cognitive and Brain Sciences

Description:

Transcranial magnetic stimulation (TMS) allows for the direct interference with brain function without any invasive procedure. This makes it an extremely valuable tool both for fundamental brain research and for clinical therapeutic and diagnostic purposes. However, to date, the full potential of the technique cannot be exploited, because the mechanism how the applied magnetic field influences brain function is yet largely uncharted. In this proposal, we will describe, by way of the example of motor evoked potentials (MEP), the entire modeling chain from the magnetic field to the observable effect. The modeling steps include (1) simulation of the electric field using advanced FEM modeling, (2) localization of stimulated neurons by non-linear regression, (3) the coupling of the electric field into the neuronal states, (4) the generation of spinal DI-waves by cortical circuits, (5) the signal transmission via spinal and peripheral pathways, (6) processing in spinal circuits, and (7) generation of MEPs in hand muscles.

Program (preliminary)

9:00-9:15
General introduction (Thomas Knösche)

9:15-9:40
E-field Modeling and TMS mapping (Konstantin Weise)

9:40-10:05
A coupling model of TMS induced electric fields into neurons and exploration of their directional sensitivity (Torge Worbs)

10:05-10:30
Identification of large-scale brain states for brain-state-dependent stimulation
(Laura Marzetti)

10:30-10:45
Break

10:45-11:10
Epidural recordings of DI-waves (Vincenzo Di Lazzaro)

11:10-11:35
Deconvolving DI waves into neural state variables and action potential propagation in long range axon fibre bundles (Helmut Schmidt)

11:35-12:00
A neural mass model of the motor cortex to model DI-waves (Aaron Miller)

12:00-12:25
A neural mass model of the spinal cord to model MEPs (Vincent Chien)

12:25-12:30
Closing Remarks (Thomas Knösche)

09:00 – 12:30 W **W03: External stimulation in visual cortex: from experiments to models** Schiller

Speakers: Jan Antolik, Matthias Kaschube, Karolína Korvasová, Mathew Chalk, Cristina Soto-Sánchez, Bodo Rückauer, David Berling, Sigrid Trägenap

Organizers:

Jan Antolik, Charles University, Prague
Matthew Chalk, Sorbonne Universite
Karolina Korvasova, Charles University, Prague

Description:

Perturbation of neural activity in the visual cortex holds immense potential for improving our understanding of how visual information is processed in the brain, as well as for the development of neuroprosthetic implants for vision restoration. To effectively communicate with the brain, it is essential to talk with it in its own language: i.e., to stimulate the visual cortex in a manner that is aligned with the representation of the visual features in its neural substrate. But to do so, we need to understand the complex interplay between the externally induced perturbation of neural activity and the recurrent on-going dynamics of cortical networks. Advanced computational methods are essential tools for such research programs, as they help us dissect this complex dynamical process into mechanistic understanding and complement the technical limitations of experimental methods. In this interdisciplinary workshop, we bring together leading experts from the computational and experimental fields to discuss novel insights into perturbation of cortical information encoding through neural stimulation.

Program:

09:00 - 09:30 Mathew Chalk (Institute de la Vision, Paris): Optimizing visual prosthetic stimulation through human feedback
09:30 - 10:00 Cristina Soto-Sánchez (Universidad Miguel Hernández de Elche): 'Neural responses to electrical stimulation in Primary Visual Cortex'
10:00 - 10:30 Bodo Rückauer (Donders Institute for Brain): 'An in-silico framework for modeling optimal control of visual prostheses'

10:30-10:45 Break

10:45-11:15 David Berling (Charles University, Prague): 'Single neuron effects are relevant for spatially precise optogenetic stimulation'
11:15-11:45 Sigrid Trägenap (Frankfurt Institute for Advanced Studies): 'Targeting the dominant modes in developing cortical networks'

11:50-12:30 Discussion

09:00 – 12:30 W **W04: Methods of Information Theory in Computational Neuroscience** Mahler

Speakers: Nadine Spychala, Benjamin Lindner, Patricio Orio, Rainer Engelken, Demian Battaglia

Organizers:

Abdullah Makkeh, University of Göttingen
Michael Wibral, University of Göttingen
Joseph T. Lizier, The University of Sydney
Pedro Mediano, Imperial College London

Program:

https://abzinger.github.io/202307-CNS2023-ITW.html

Description:

Methods originally developed in Information Theory have found wide applicability in computational neuroscience. Beyond these original methods, there is a need to develop novel tools and approaches that are driven by problems arising in neuroscience.

A number of researchers in computational/systems neuroscience and in information/communication theory are investigating problems of information representation and processing. While the goals are often the same, these researchers bring different perspectives and points of view to a common set of neuroscience problems.

Often they participate in different fora and their interaction is limited.
The goal of the workshop is to bring some of these researchers together to discuss challenges posed by neuroscience and to exchange ideas and present their latest work.

09:00 – 12:30 W **W05: Multiscale modeling of cerebral cortex, from neural circuits to whole brain models** Telemann

Speakers: Leonardo Dalla Porta, Giulia Moreni, Gorka Zamora-López, Mihai A. Petrovici, Pier Stanislao Paolucci, Rajanikant Panda, Alain Destexhe, Galyna Malieieva, Johanna Senk

Organizers:

Alain Destexhe, CNRS, Paris-Saclay University

Program:

Day 1 - Tuesday, July 18
Spiking networks
09:00 : Alain Destexhe, welcome
09:10 : Johanna Senk (Julich Research Center, Germany), "A mesoscopic layered cortical network model for spiking activity and local field potentials "
09:40 : Mihai Petrovici (University of Bern, Switzerland), "Credit assignment in cortical structures",
10:10 : discussion
10h20-10h50 : coffee break
10:50 : Leonardo Dalla Porta (IDIBAPS, Barcelona, Spain), " Modelling cholinergic modulation of cortical brain sates: from cellular to whole-brain level"
11:20 : Alain Destexhe (CNRS, Paris-Saclay University, France), "Mean-field models as a bridge between spiking network models and neural populations".
11:50 : discussion

Description:

In this workshop we will overview modeling approaches at different scales and levels of modeling, starting from the level of circuits and their modulation. In this case, tools such as NEST or BRIAN are typically used to construct and simulate the networks. This will be illustrated for various levels of simplification, from detailed microcircuit models, multilayer models of point neurons, large-scale point neuron models, and simplified models consisting of two populations of spiking neurons, excitatory and inhibitory neurons. This will include the inclusion of synaptic plasticity, neuromodulation and how to model sleep cycles.

Second, we will illustrate the « mesoscale », at sizes of millimeter of cortical tissue, typically recorded using mesoscale signals, such as local field potentials, calcium imaging or voltagesensitive dye imaging. Here, we will show the use of mean-field techniques to design population models from the spiking networks. The population models are validated using the networks of spiking neurons, as well as from experimental data when available. In particular mesoscale phenomena such as propagating waves can be used to constrain such models.

Third, we will scale up the models to the whole brain level, for mouse, monkey and human. In this case, the experimental data consist of macroscopic measurements such as the electroencephalogram, magneto-encephalogram, or functional MRI. Here, we will illustrate how to build a whole-brain model using mean-field models, and using python-based « The Virtual Brain » tool. In this scale of the whole brain, we will illustrate the genesis of both spontaneous activity states in the wake-sleep cycle or during anesthesia, and the evoked response to external stimuli in such states.

At each stage of this oveview, we will illustrate the construction of the models, and their simulation, using the EBRAINS research infrastructure.

09:00 – 12:30 W **W06: Optimality, evolutionary trade-offs, Pareto theory and degeneracy in neuronal modelling** Leibniz

Speakers: Peter Jedlicka, Zahid Padamsey, Philipp Norton, Astrid Prinz, Anna Levina, Rishikesh Narayanan

Organizers:

1. **Alexander Bird** (Justus-Liebig University, Giessen & Ernst Strüngmann Institute, Frankfurt)
2. **Philipp Norton** (Humboldt University, Berlin)
3. **Peter Jedlicka** (Justus-Liebig University, Giessen & Ernst Strüngmann Institute, Frankfurt)
4. **Susanne Schreiber** (Humboldt University, Berlin)

Full program: https://www.treestoolbox.org/CNS2023_pareto_workshop/index.html

Description:

Nervous systems, like any evolved structure, encounter unavoidable trade-offs between multiple tasks. They must fulfil their fundamental computational functions whilst consuming as little energy as possible (1) and remaining robust to potential environmental changes. These tasks are often in direct opposition to one another, and a general quantification of the relative importance of individual optimisation targets is non-trivial. The problem is complicated by the degeneracy seen across neurons and circuits, where multiple different combinations of components can lead to similar functional behaviours (2,3). Pareto optimality (4) might provide a useful framework to analyse neurobiological systems (5) from biophysically-detailed cells (6) to large-scale network structures that combine high-dimensional parameter spaces with high-dimensional objective spaces. Pareto, or multi-objective, optimality can, for example, help to identify geometrically simple subspaces of neuronal models that cannot be improved upon for all relevant objectives (7,8,5,6). This workshop aims to discuss applications of Pareto optimality to the trade-offs encountered by diverse nervous systems. The talks and discussions will also address the trade-off between functional effectiveness and energetic efficiency and the concept of metabolically efficient information processing (9).

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2. Edelman GM, Gally JA. 2001 Degeneracy and complexity in biological systems. Proc. Natl Acad. Sci. USA 98, 13763–13768.
3. Goaillard JM, Marder E. 2021 Ion channel degeneracy, variability, and covariation in neuron and circuit resilience. Annu. Rev. Neurosci. 44, 335–357.
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5. Pallasdies F, Norton P, Schleimer JH, Schreiber S. 2021 Neural optimization: Understanding trade-offs with Pareto theory. Curr. Opin. Neurobiol. 71, 84–91
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9. Stone J. 2018 Principles of neural information theory: computational neuroscience and metabolic efficiency. Sebtel Press.

09:00 – 12:30 W **W07: The impact of photopharmacology on brain circuits research: present and future prospects** Lessing

Speakers: Galyna Malieieva, Alexandre Gomila Juaneda

Organizers:

Galyna Malieieva, Institute for Bioengineering of Catalonia
Alexandre Gomila, University of Barcelona

Description:

Neuronal circuits research is key for understanding the puzzles of brain functioning. Significant advances have been made in brain circuit research using optogenetics and photopharmacology. In particular, photopharmacology has been shaping the advancement of neuroscience, enabling the control of the essential blocks of neuronal transmission, single neurons, and behavioural patterns.
Our workshop gathers outstanding researchers from the fields of molecular modelling, photopharmacology and brain circuits to bring closer neuroscience experimentalists and the state-of-art computational tools for studying brain connectivity. The relevance of the proposed workshop also consists of examining the prospect of the impact of photopharmacology as an approach to brain circuit discovery and brain therapy development.
The workshop will be made of five presentations and a panel discussion. The panel will identify the photopharmacology and computational bottlenecks and discuss solutions for overcoming them and converting photopharmacology into a technique of choice for brain circuit research and therapeutic use.

JULY 19 • WEDNESDAY

09:00 – 12:30 W **W02: Evidence, value, and action: from cortex to behavior, and everything in between** Lessing

Speakers: Jonathan Rubin, Fred Hamker, Jyotika Bahuguna, Robert Schmidt, Clay Holroyd, Elodie Fino, Christelle Baunez, Anke Braun, Elisabet Pares-Pujolras, Laurent Venance

Organizers:

Jonathan Rubin, University of Pittsburgh
Jyotika Bahuguna, Carnegie Mellon University

Description:

Organisms interact with the environment through behavior. Selecting which behaviors to implement, and how to implement them, based on evidence, perceived value of actions, and experience, is critical to survival and reproductive success. Corresponding to the central importance of these topics in neuroscience, there has been a plethora of recent activity in the field of computational neuroscience to test ideas and generate predictions about how these tasks are performed. This activity ranges from the development and analysis of mathematical frameworks to the development and simulation of data-driven models across a range of scales. With such diverse and exciting current activity in this area, an OCNS workshop represents an ideal opportunity to bring together researchers representing a range of approaches, including some who have been involved in cutting-edge experiments, to exchange ideas and to create the chance to advance the field by integrating work on different aspects of this problem.

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Organizers:

Alain Destexhe, CNRS, Paris-Saclay University

Program:

Day 2 : Wednesday July 19
Neural populations and large-scale models :
09:00 : Galyna Malieieva (IBEC, Barcelona, Spain), "Photopharmacology as an approach for studying and controlling neuronal activity"
09:30 : Giulia Moreni (University of Amsterdam, Holland), “Emergence of oscillations in a biologically realistic model of a V1 cortical column”,
10:00 : Pier-Stanislao Paolucci (INFN, Rome, Italy), "Apical-amplification, -drive and -isolation in plastic modules entering wakefulness, REM and NREM. contributing to whole-brain cognitive simulation blue-printing”
10h30-10h50 : coffee break
10:50 : Gorka Zamora-Lopez (University Pumpeu Fabra, Barcelona, Spain), "Whole-brain analyses reveal the impairment of posterior integration and thalamo-frontotemporal broadcasting in disorders of consciousness"
11:20 : Rajanikant Panda (University of Liege. Belgium), "Characterizing structural-functional network repertoire and time-resolved subcortical-cortical connectivity in disorders of consciousness"
11:50: discussion
12:00 : end of the workshop

Description:

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09:00 – 12:30 W **W06: Optimality, evolutionary trade-offs, Pareto theory and degeneracy in neuronal modelling**
Speakers: Alexander Bird, Dylan Festa, Susanne Schreiber, Arnd Roth, Suhita Nadkarni, Marcel Leibniz *Oberländer*
Organizers:

1. **Alexander Bird** (Justus-Liebig University, Giessen & Ernst Strüngmann Institute, Frankfurt)
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09:00 – 12:30 W **W08: Neuroscience Gateway Enabling Neuroscience Software Dissemination and Large-Scale Neuronal Modeling and Data Processing on Supercomputers** Goethe

Speakers: Amitava Majumdar, Robert McDougal, Padraig Gleeson, Subhashini Sivagnanam, Kenneth Yoshimoto, Ted Carnevale, William W Lytton, Anirban Datta, Luca L. Bologna

Organizers:

Amit Majumdar, San Diego Supercomputer Center
Subhashini Sivagnanam, San Diego Supercomputer Center
Ted Carnevale, Yale University
Kenneth Yoshimito, San Diego Supercomputer Center

Description:

The Neuroscience Gateway (NSG) has been enabling large scale modeling and data processing for the neuroscience community for about a decade. It provides about twenty neuroscience software for modeling, data processing and AI/ML on supercomputers. Examples of these software are NEURON, NEST, NetPyNE, PyNN, BMTK, BluePyOpt, PGENESIS, Brian2, HNN Core, EEGLAB, FreeSurfer, TensorFlow, PyTorch etc. It is free and open to students and researchers from any country. NSG eliminates administrative and technical barriers to using supercomputers for neuroscience research. The NSG team acquires over 20,000,000 core hours per year on academic supercomputers and fairly distributes to NSG users; NSG currently have over 1,500 users. NSG is also a platform for dissemination of neuroscience software. The workshop speakers are both users of NSG for neuroscience research as well as developers of software that are disseminated via NSG. This workshop will provide the perspective of both users and developers of software regarding how NSG is enabling neuroscience research, training and classroom teaching.

09:00 – 12:30 W **W12: Multiscale spatial and temporal neural computation** Schiller

Speakers: Andre Peterson, Brian Lundstrom, Christian Meisel, Anna Levina, Michael Wenzel, Tom Richner, Audrey Sederberg

Organizers:

Brian Lundstrom, Mayo Clinic, Rochester, Minnesota, USA,
Christian Meisel, Charité–Universitätsmedizin Berlin

Program:

9:00-9:20 Timescales of neural computation – Anna Levina, Univ Tuebingen
9:20-9:40 Multiscale recordings, neural excitability and epilepsy – Michael Wenzel, Univ Bonn
9:40-10:00 Estimating patient-specific spatiotemporal scales for brain state transitions – Andre Peterson, Univ Melbourne
10:00-10:20 Discussion
10:20-10:50 Break
10:50-11:10 Gain control, adaptation, and fractional dynamics – Brian Lundstrom, Mayo Clinic
11:10-11:30 Power laws in spiking data: why so many? – Audrey Sederberg, University of Minnesota
11:30-11:50 Network stability and fractional dynamics – Tom Richner, Mayo Clinic
11:50-12:10 Spatial and temporal correlations in human cortex – Christian Meisel, Charité–Universitätsmedizin Berlin
12:10-12:30 Discussion

Description:

Understanding multiscale behavior of the nervous system is a primary challenge of 21st century neuroscience. Neuroscience has often focused on single space and time scales. However, data suggest neural activity often exhibits multiscale and scale-free spatial and temporal patterns, indicating the importance of a broad range of scales. In addition, large datasets across space and time are a challenge for traditional approaches that focus on single scales. New frameworks for understanding these data are needed.

Dynamical and statistical approaches that incorporate multiple spatial scales and timescales are critical to understand efficient coding, predict responses, and maintain network stability. Understanding how properties at the single neuron or small circuit level affect whole brain dynamics and responses is also of broad appeal. We aim to bring together experimentalists and theoreticians who study multiscale neural computation, including power-law statistics, brain state transitions, criticality, and fractional order dynamics. This session will provide novel frameworks for integrating multiple spatial and temporal scales.

09:00 – 17:50 W **W04: Methods of Information Theory in Computational Neuroscience** Mahler

Speakers: Marilyn Gatica, Pedro Mediano, Maria Pope, Andres Canales-Johnson, Sarah Marzen, Jürgen Jost, Andreas Schneider

Organizers:

Abdullah Makkeh, University of Göttingen
Michael Wibral, University of Göttingen
Joseph T. Lizier, The University of Sydney
Pedro Mediano, Imperial College London

Program:

https://abzinger.github.io/202307-CNS2023-ITW.html

Description:

Methods originally developed in Information Theory have found wide applicability in computational neuroscience. Beyond these original methods, there is a need to develop novel tools and approaches that are driven by problems arising in neuroscience.

A number of researchers in computational/systems neuroscience and in information/communication theory are investigating problems of information representation and processing. While the goals are often the same, these researchers bring different perspectives and points of view to a common set of neuroscience problems.

Often they participate in different fora and their interaction is limited.
The goal of the workshop is to bring some of these researchers together to discuss challenges posed by neuroscience and to exchange ideas and present their latest work.

09:00 – 17:50 W **W09: Graph modeling of macroscopic brain functional activity dynamics** Schumann

Speakers: Thanos Manos, Mark Woolrich, Leonardo Novelli, Rezvan Farahibozorg, Giovanni Rabuffo, Alessandra Griffa, Patricio Orio, William W Lytton, Parul Verma, Ashish Raj

Organizers:

Parul Verma, University of California San Francisco, USA
Ashish Raj, University of California San Francisco, USA

Program:

https://raj-lab-ucsf.github.io/cns2023/program/

Description:

Recent neuroimaging studies indicate that the brain's functional activity does not remain static even while resting - it constantly switches between *micro-states*, which are temporal fluctuations in its functional activity. The pattern of micro-state switching varies in different neurological diseases. Currently, the mechanism of micro-state switching is unclear and various statistical and mathematical modeling approaches are being undertaken to investigate its biophysics. In this workshop, we have put together recent statistical and mathematical modeling efforts aimed towards understanding micro-state switching. We focus largely on graph-based macroscopic systems for this purpose, since at the macroscopic scale, brain regions interact with each other via long range projection fibers – a network organization that is best addressed using graph theory. Graph theory is not currently included in training for neuroscientists with a background in biology or physiology; conversely, computational neuroscientists are steeped in fine-scale neuronal models but may be unfamiliar with the more abstract graph theoretic approaches.

09:00 – 17:50 W **W10: Neuro-Inspired Topology and Machine Learning** Bach

Speakers: Robert McDougal, William W Lytton, Claudia Clopath, Maxim Bazhenov, Salvador Dura-Burnal, Celia Hacker, Erik Hermansen, Aitor Morales-Gregorio, Brittany Story, Nick Tolley, Manish Saggar, Vasileios Christopoulos

Organizers:

Brittany Story, University of Tennessee Knoxville
Vasileios Maroulas, University of Tennessee Knoxville
Sam Neymotin, The Nathan S. Kline Institute for Psychiatric Research

Program:

https://sites.google.com/view/nitmlcns2023/home

Description:

Mathematics, machine learning, and computational neuroscience have long been intertwined. Mathematical tools such as graph theory, information theory and dynamical systems have been used to model neural activity. Similarly, modern machine learning approaches have been inspired by neuroscience and have been used to better understand brain connectivity and dynamics. These three research facets play off of each other to advance each field individually and concurrently. The goal of this workshop is to bring computational neuroscientists, mathematicians, and computer scientists together to communicate research around their expertise. Additionally, it will serve as a venue to discuss avenues of future research impacting computational neuroscience and mathematics while advancing machine learning and artificial intelligence methods.

09:00 – 17:50 W **W11: Multiscale personalized brain network modelling: Towards clinical applications** Handel

Speakers: Jil Mona Meier, Petra Ritter, Patrik Bey, Christoph Hüttl, Leon Martin, Jeehye An, Leon Stefanovski, Valery Bragin, Anaïs Halimi, Taher Halgurd, Julie Courtiol

Organizers:

Petra Ritter, Berlin Institute of Health at Charité Universitätsmedizin
Julie Courtiol, Berlin Institute of Health at Charité Universitätsmedizin

Program:

https://www.brainsimulation.org/bsw/zwei/events/single/12404-32nd-annual-computational-neuroscience-meeting

Workshop materials:

An EBRAINS account is required to access the workshop materials.
Register for FREE with your institutional email address at: https://www.ebrains.eu/page/sign-up

Description:

Technological advances in the field of personalized brain network modeling are being made at a breathtaking pace – and the healthcare sector is not spared from these developments. Multiscale simulations, simulation-based inference, cloud infrastructure for compute intense processing of digital brain twins, AI and robotics interfaces, and clinical validation of computational model bases decision making – are just a few examples of the latest developments. While many potential solutions to address clinical needs are already prototyped or tested in our labs, they also need testing in real-life environments and certification. In addition to presenting the latest advances in the field, we introduce, TEF-Health - a world class reference Testing and Experimentation Facility Health AI and Robotics that integrates expertise and infrastructure necessary for the design and implementation of digital human brain twin testing methods in real world environments.

The workshop will provide insight in the interdisciplinary work and related challenges that range from computational and clinical neuroscience to digital infrastructure, reproducible research, and legal and ethical matters when working with human digital twins.

14:10 – 17:50 W **W02: Evidence, value, and action: from cortex to behavior, and everything in between** Lessing

Speakers: Jonathan Rubin, Fred Hamker, Jyotika Bahuguna, Robert Schmidt, Clay Holroyd, Elodie Fino, Christelle Baunez, Anke Braun, Elisabet Pares-Pujolras, Laurent Venance

Organizers:

Jonathan Rubin, University of Pittsburgh
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Description:

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14:10 – 17:50 W **W13: Low-dimensional manifolds of neural dynamics and their role in brain function** Telemann

Speakers: Helmut Schmidt, Richard Gast, Ann Kennedy, Juan Alvaro Gallego

Organizers:

Richard Gast, Northwestern University, Chicago
Helmut Schmidt, Institute of Computer Science, Czech Academy of Sciences, Prague

Description:

One of the big challenges of neuroscience and artificial intelligence research is to explain how computations arise from the interaction of recurrently coupled neurons. Recent research suggests that the phase-space properties of low-dimensional manifolds that emerge in recurrent neural networks might represent important aspects of neural computation. Can these phase-space properties of low-dimensional manifolds be captured by mathematical models, such as mean-field equations? How do low-dimensional dynamics of neural populations relate to brain function? Can this view of neural computation be applied to more macroscopic scales of brain organization as well?

In this workshop we bring together researchers that address these questions via experimental and theoretical approaches. We will discuss low-dimensional manifolds discovered in in-vivo recordings of neural activity, examine how they relate to on-going behavior, and study mathematical models that aim for a mechanistic explanation of these phenomena.

Schedule:

14:10 – 14:20 Introduction (Richard Gast and Helmut Schmidt)
14:20 – 14:50 **Juan Gallego**: *Presented neural population dynamics across animals performing similar behaviour*
14:50 – 15:20 **Lea Duncker**: *Dynamical mechanisms underlying robust computation in neural populations*
15:20 – 15:50 – coffee break –
15:50 – 16:20 **Ann Kennedy:** *Neural population dynamics underlying hypothalamic regulation of motivated behavior*
16:20 – 16:50 **Adrian Valente**: *Extracting computational mechanisms from neural data using low-rank RNNs*
16:50 – 17:20 **Bill Podlaski**: *Computation with latent boundaries in low-rank excitatory-inhibitory spiking networks*
17:20 – 17:50 **Brian DePasquale**: *Constructing spiking networks as a foundation for the theory of manifolds as computational substrate*
17:50 – 18:00 Closing remarks (Richard Gast and Helmut Schmidt)

14:20 – 15:50 W **W06: Optimality, evolutionary trade-offs, Pareto theory and degeneracy in neuronal modelling**
Speakers: Timothy O'Leary, Albert Gidon, Wiktor Mlynarski Leibniz
Organizers:

1. **Alexander Bird** (Justus-Liebig University, Giessen & Ernst Strüngmann Institute, Frankfurt)
2. **Philipp Norton** (Humboldt University, Berlin)
3. **Peter Jedlicka** (Justus-Liebig University, Giessen & Ernst Strüngmann Institute, Frankfurt)
4. **Susanne Schreiber** (Humboldt University, Berlin)

Full program: https://www.treestoolbox.org/CNS2023_pareto_workshop/index.html

Description:

Nervous systems, like any evolved structure, encounter unavoidable trade-offs between multiple tasks. They must fulfil their fundamental computational functions whilst consuming as little energy as possible (1) and remaining robust to potential environmental changes. These tasks are often in direct opposition to one another, and a general quantification of the relative importance of individual optimisation targets is non-trivial. The problem is complicated by the degeneracy seen across neurons and circuits, where multiple different combinations of components can lead to similar functional behaviours (2,3). Pareto optimality (4) might provide a useful framework to analyse neurobiological systems (5) from biophysically-detailed cells (6) to large-scale network structures that combine high-dimensional parameter spaces with high-dimensional objective spaces. Pareto, or multi-objective, optimality can, for example, help to identify geometrically simple subspaces of neuronal models that cannot be improved upon for all relevant objectives (7,8,5,6). This workshop aims to discuss applications of Pareto optimality to the trade-offs encountered by diverse nervous systems. The talks and discussions will also address the trade-off between functional effectiveness and energetic efficiency and the concept of metabolically efficient information processing (9).

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2. Edelman GM, Gally JA. 2001 Degeneracy and complexity in biological systems. Proc. Natl Acad. Sci. USA 98, 13763–13768.
3. Goaillard JM, Marder E. 2021 Ion channel degeneracy, variability, and covariation in neuron and circuit resilience. Annu. Rev. Neurosci. 44, 335–357.
4. Shoval O, Sheftel H, Shinar G, Hart Y, Ramote O, Mayo A, Dekel E, Kavanagh K, Alon U. 2012 Evolutionary trade-offs, Pareto optimality, and the geometry of phenotype space. Science 336, 1157–1160.
5. Pallasdies F, Norton P, Schleimer JH, Schreiber S. 2021 Neural optimization: Understanding trade-offs with Pareto theory. Curr. Opin. Neurobiol. 71, 84–91
6. Jedlicka P, Bird AD, Cuntz H. 2022 Pareto optimality, economy-effectiveness trade-offs and ion channel degeneracy: improving population modelling for single neurons. Open Biol. 12:220073.
7. Druckmann S, Banitt Y, Gidon A, Schürmann F, Markram H, Segev I. 2007 A novel multiple objective optimization framework for constraining conductance-based neuron models by experimental data. Front. Neurosci. 1, 7–18
8. Remme MWH, Rinzel J, Schreiber S. 2018 Function and energy consumption constrain neuronal biophysics in a canonical computation: Coincidence detection. PLoS Comput Biol. 14:e1006612.
9. Stone J. 2018 Principles of neural information theory: computational neuroscience and metabolic efficiency. Sebtel Press.