Plenary session talk abstracts

Plenary session 1

Service Categorie 1: EBRAINS FAIR data services: data sharing for collaborative neuroscience

Ida Aasebø and Lyuba Zehl: Data sharing is becoming the new standard in science. An increasing number of researchers are recognizing the benefits of sharing research data and computational models to obtain greater exposure of their research and to access shared data assets for re-analysis and re-use in new combinations. Data sharing also addresses reproducibility challenges that are currently manifested across all scientific disciplines. Many services for data sharing are available but few provide the necessary stewardship and standards for making the research data and models Findable, Accessible, Interoperable and Reusable (FAIR). To address these challenges, we in the Human Brain Project (HBP) are developing EBRAINS FAIR data service, providing tools, workflows and curation services tailored for integration and sharing of heterogeneous, multimodal neuroscience data and computational models. In this talk we will describe the basics steps of the curation process and the development of openMINDS, a flexible metadata schema for heterogeneous neuroscience data.

Plenary session 2

Service Categorie 2: Brain atlas services: navigate the brain in 3D - find, contribute, and analyse brain data, based on location.

Timo Dickscheid: EBRAINS brain atlases are the entry point for finding, organizing and analysing data based on location in the brain. Via an interactive atlas viewer, users can explore reference atlases of the human and rodent brains at different scales in 3D, and browse EBRAINS data repositories by selected brain regions, comparable to the way Geographical Information Systems organize data in 2D maps of the earth surface. Several tools are available for analyzing neuroscientific data in relation to brain regions, some of which can be directly used in the atlas viewer. In addition, EBRAINS provides interactive services for integration of 2D and 3D data to this spatial reference framework. This talk will give an overview of the atlas services available, and discuss some future directions.

Markus Axer: During SGA2, a key multimodal dataset for nested connectome analysis in one post mortem human hippocampus was acquired, assembled, and anchored to the BigBrain atlas provided by EBRAINS (SP2, WP2.3, T2.3.3 and T2.3.4). We established protocols and workflows across laboratories that made joint post mortem brain tissue scanning possible by sequentially applying anatomical and diffusion magnetic resonance imaging (MRI), 3D polarized light imaging (3D-PLI), and two-photon fluorescence microscopy (TPFM). By this means a unique multimodal dataset was generated that addresses spatial scales in the hippocampus ranging from 300 m down to 0.4 m (in selected sections).
To integrate this research data into the EBRAINS brain atlas, we aligned the dataset to the BigBrain reference linearly by using the interactive anchoring tool Voluba, which is part of the EBRAINS atlas services. The design of a robust registration framework utilizing landmarks is an essential step to render sophisticated

aggregation of data acquired at different scales, from different imaging techniques, in selected volumes of interest, possible. In the presented use case, the alignment of sub-volumes into the well-characterized BigBrain enhanced classification of neuroanatomical structures / brain regions and supported data navigation in a whole-brain context.

Xiao Gui: A common problem in high-resolution brain atlasing is spatial anchoring of high-resolution volumes of interest (VOIs) from specific imaging experiments into the detailed anatomical context of a high-resolution reference model like BigBrain (Amunts et al., 2013), to allow integration of partial volumetric data at the level of cortical areas, individual cortical layers or subcortical structures. Downloading and interacting with reference templates of whole human brains at microscopic resolution is out of reach for many neuroscientists due to the sheer size of such data, as well as the lack of practical tools. EBRAINS atlas services include a web service for interactive volumetric alignment of such user-provided VOIs to very large reference volumes. The resulting transformation parameters can be downloaded for reference and for submission to HBP data curation. The aligned image volume can be directly opened in EBRAINS' interactive atlas viewer to view the VOI in anatomical context, compare it to atlas regions, and access data linked to the region of interest. The talk will give a tour of interactive data integration, and give a preview of features of upcoming releases.

Camilla Blixhavn/Ingrid Reiten and Anna Kreshuk: Integrating data based on their location within a common atlas framework enables new opportunities for researchers sharing or re-using data. The EBRAINS atlas services allow users to find, view and combine spatially relevant data. We here show how new EBRAINS services allow us to extract features using the machine learning tool ilastik while utilizing location metadata and reference atlases, and exemplify some of the new opportunities for sharing, discovering and analyzing data integrated in EBRAINS.

<u>Plenary session 3</u>

Service Category 3: Brain modeling and simulation workflows: integrated tools to create and investigate models of the brain

Susanne Kunkel: EBRAINS integrated digital workflows at multiple scales allow users to perform complex computational experiments, including large-scale simulations, model validation, analysis and visualization. The components of EBRAINS created by SC3 support multiscale modeling and co-simulation where a model at a coarse level of description provides the embedding for a more detailed one. Workflows addressing the needs of scientists across disciplines and levels of expertise as well as the classroom are accessible through web applications and flexible digital notebooks. EBRAINS constitutes a generic infrastructure designed for long-term operation and improvement as a world-wide unique scientific instrument and is independent of any particular mathematical brain model. The conceptual separation between mathematical models and a generic infrastructure is the result of decades of research and has recently been formally described by SC3 researchers in Einevoll et al. (2019). Thus, SC3 provides the means to deploy models owned by teams of neuroscientists, but does not engage in the development of brain models. EBRAINS overcomes the complexity barrier in brain modeling by digitization of the full modeling process and enabling the use of models as building blocks for larger ones. This session presents the key components of EBRAINS offered by SC3 in the area of simulation, validation, and visualization.

Sandra Diaz: The brain is a multiscale system and the right tools are required in order to understand each level of detail and address the current scientific and applications-oriented questions emerging in the community. The HBP has not only been a platform for the development and refinement of efficient, robust, optimized, fast and flexible simulation engines, it has also as flourished a cooperative environment for these simulators and their communities to work together towards the final goal of understanding the brain. Since the beginning, the HBP has promoted best software development practices, reproducibility and standardization among the software tools which once had their own corner in the field of neuroscience. This presentation will highlight the status of each simulation engine developed within the HBP at the end of SGA2. As showcases I will present how neuroscientists already employed the simulation technologies developed since the beginning of the HBP to advance our understanding of brain function. Finally, I will provide an overview of the plans for SGA3 at each scale, focusing on integration with the complete EBRAINS infrastructure and highlighting the benefits that SGA3 will bring for education, science, and industry.

Wouter Klijn: The brain is an inherently multiscale system and the interplay between these scales remains an open question: Efficient simulation at each scale is critical, but not sufficient for understanding the whole system. SGA2 sees the completion of four interrelated proof of concepts providing fundamental insight into the requirements of co-simulation: NEST-TVB coupling, NEST-Arbor coupling, in transit analysis using Elephant and in-situ visualization of NEST and Arbor.
During SGA3, EBRAINS will deliver a modular framework for connecting models and simulation engines working at different or the same scales. It will include in situ analysis and communication infrastructure and science workflows that will provide the neuroscience community with novel tools for researching the multiscale nature of the brain. Co-simulation in EBRAINS is designed for large-scale deployment on HPC, including the necessary transducing modules between simulators and integration with EBRAINS tools for parameter space exploration, analysis, and visualization. This presentation will discuss the use cases and showcases guiding the work in SGA3.

Michael Denker: Neuroscientists have a diversified and constantly growing repertoire of methods at their disposal in order to analyze neuronal activity data across spatio-temporal scales and measurement modalities. Moreover, the availability of open data sets containing neuronal activity data puts modelers in a position to perform a more in-depth validation of their models based on the statistical descriptions of the activity observed in experiments. However, the increased possibilities come at the cost of higher complexity of such analysis and validation processes. Here, we showcase the state of tool-based workflow solutions that implement rigorous and well-defined data handling and analysis, as well as model validation schemes for activity data such as spike trains or local field potentials. We demonstrate methods for data analytics using multiple emerging open-source software tools. Analysis is performed using the Electrophysiology Analysis Toolkit (Elephant) as a community-centered analysis framework for parallel, multi-scale activity data developed within the HBP, while validation is carried out using the HBP validation framework, and in particular the NetworkUnit library. The interplay between the tools is showcased by integrating them into a robust workflow solution. Concrete examples on how to utilize these tools for scientific discovery in conjunction with the Collaboratory and Knowledge Graph HBP infrastructure components as well as workflow tools, are given in the context of the use cases developed during SGA2. We outline the goals and future steps to integrate analysis and validation into the emerging EBRAINS landscape.

Benjamin Weyers: The EBRAINS research infrastructure does not only offer access to data, services and resources but also provides the right tools to enable researchers with different levels of expertise (from student to experts) to use the infrastructure to its full potential. A novel approach to achieve this goal in the case of computational neurosciences, is by offering interactive modeling, simulation and interpretation of simulation results in a comprehensive and easy-to-use environment, with the computations running remotely. This talk presents NEST Desktop, a web-based tool that implements a user interface for the simulation code NEST. NEST Desktop is a well-targeted and co-developed tool for school and university education and thus to promote EBRAINS for teachers and students by enabling students to create simple network models for NEST using a visual and easy to use point and click graphical user interface. Created models can then be simulated on a server-side running NEST simulator where the resulting data can be directly visualized and analyzed. Furthermore, this feature set has the potential to be used for fast prototyping of models and, thus, get an integral tool in computational neuroscience workflows. NEST Desktop combines previously developed and released web-based tools for the interactive creation and analysis of NEST-based simulation models. NEST Desktop is integrated into EBRAINS through an HBP voucher and builds on infrastructure provided by FENIX.

Plenary session 4

Service Category 4: Learning and embodiment: Connecting cognitive architecture to function

Wolfgang Maass: Two new methods boost the performance of next generation learning in spiking neural networks: 1. The inclusion of adapting neurons enables us to approach the level of human performance for many temporal computing tasks (such as speech recognition, question-answering), 2. E-prop: a biologically inspired learning method for recurrent neural networks enables us to run powerful Deep Reinforcement Learning on spike-based neuromorphic hardware, such as SpiNNaker.
For details see: G. Bellec, F. Scherr, A. Subramoney, E. Hajek, D. Salaj, R. Legenstein, and W. Maass. A solution to the learning dilemma for recurrent networks of spiking neurons. bioRxiv/org/10.1101/738385v3, December 2019.
https://igi-web.tugraz.at/PDF/248.pdf

Vaishnavi Narayanan: The brain can be perceived as implementing a cognitive architecture whose capacities serve a purpose. This *teleological* perspective, highlighting the function of neural structures, proceeds by decomposing complex functions into a set of simpler interacting modules. We exploit this modular approach to implement visuomotor tasks with different modelling methods of varying levels of biological realism. We previously developed a closed-loop model of saccades for object recognition, consisting of modules ranging from deep learning to spiking neuron models. Our next goal involves modelling hand-eye coordination for in-hand object manipulation combined with reaching towards and grasping the object.

Plenary session 5

Service Category 5: Leveraging Human Intracerebral EEG Research through EBRAINS

Philippe Ryvlin: Human intracerebral EEG (iEEG) recordings, primarily captured from patients with epilepsy undergoing pre-surgical evaluation of their epilepsy, offer a unique window into human neuronal and brain physiology and dysfunctions. Single neuron, multi-units and local field potentials can be recorded in a large range of cognitive activities with a temporal resolution unavailable in other investigations of the Human brain. It can inform on virtually all Human brain functions such as sleep and consciousness. The Human Intracerebral EEG Platform (HIP) aims at leveraging access to such precious and rare data by providing unique functionalities to curate share and analyze iEEG data, while organizing a network of the 30 most active European epilepsy centers performing such investigations.

Eloise Gronlier: This talk will summarize the activity of the Medical Informatics Platform on the use of intracranial electrophysiological (iEEG) data.
The activity of the consortium (WP8.8) has been centered on the use of cortico-cortical evoked potentials (CCEPs) recorded during direct cortical stimulations performed in epileptic patients who were candidates to respective surgery. Responses to stimulations are indeed particularly interesting for studying brain connectivity and for developing whole brain models.
Our first focus was to develop a data format able to handle large datasets of iEEG data. During the presentation, we will thus introduce the iEEG-BIDS solution which was defined by an international consortium. Then we will show how one can process iEEG BIDS data format. The presentation will conclude with scientific results on the mapping of brain connectivity and neural properties obtained from the use of a multicentre database of CCEPs.

Petra Ritter: We will demonstrate how with multi-scale simulations of patient digital brains - using The Virtual Brain framework - we merge multimodal measurements in a single consistent brain model and how this helps patients. By integrating all available observations - including intracerebral EEG - in a single consistent patient model, we learn how the different pieces of information - measured at different temporal and spatial scales with different techniques – sometimes across different species - are linked together mechanistically. We learn to understand multi-scale processes including those underlying brain diseases. TVB has been used in stroke, epilepsy, brain tumors, schizophrenia, dementia and other brain disorders. HBP’s Codesign Project #8 ‘The Virtual Brain’ made the simulation software, supporting workflows and simulation-ready patient data available on HBP’s informatics infrastructure so that every scientist can build brain avatars for their patients (or use existing ones) and run individualized simulations to address their specific research or clinical questions.

Plenary session 6

Service Categorie 6: Interactive workflows on HPC or NMC: Europe-wide access to scalable and interactive compute services

Plenary session 7

EBRAINS beyond 2023

Lars Klüver: The inclusive EBRAINS Community is to become an infrastructure of people and organizations that goes hand in hand with the technical infrastructure. Great science, impactful projects and new benefits to society will depend on our ability to create new collaborations across boundaries. That will be an important role for the EBRAINS Community. The EBRAINS Community will recruit and engage EBRAINS users, EBRAINS Supporters and a variety of collaborators and stakeholders. The community will be built during SGA3 and will be a core activity for the future use and further development of the infrastructure after the end of HBP.

Guillermo Velasco: After years of intensive research, HBP is facing the exploitation ´momentum´. Some HBP mature tools and services are already supporting neuroscience communities´ work and certainly many more scientific and industrial users are about to come. In the upcoming years, the Innovation strategy of HBP will focus in accelerating the engagement of new commercial and non-commercial users to EBRAINS and laying the basis of a legacy that, driven by effective inertial forces, guarantees the sustainability of the HBP infrastructure and launched innovation processes beyond the project end.

Spotlight Talks

Arleen Salles: Neuroscience in society: present and future

Since the beginning of the HBP, societal, ethical and philosophical issues have been a core research focus, complementing and enhancing research in neuroscience and technology. Recently we have, together with members of the IBI neuroethics working group, identified a number of central ethical questions to guide current and future brain research, some of which we have addressed in papers and in practice. Taking some of them as illustration, I shall here briefly address the issue of ethical priorities and the relevance of ethical and social analysis, noting that many - maybe most - of these issues are simultaneously short, mid, and long term and not necessarily to be distinguished by those categories.