Session 1 9:05-9:35

[Presenter]
Akihiro Funamizu
Institute for Quantitative Biosciences (IQB), the University of Tokyo

[Title]
Integration of prior knowledge and sensory evidence on brain and AI

[Abstract]
I first joined Doya lab as a short-term visitor when I was a Ph.D student in 2008. After 12 years of long journey, I finally start my own lab from March 2020. Our lab focuses on (i) how the brain perceives sensory inputs, (ii) how the sensory perception is affected by prior knowledge of external world, and (iii) how the integrations of sensory and prior in the brain are different from (or like) machine learning algorithms. Currently, we are interested on how mice estimate the transition of sensory stimuli to guide behavior. Although the transition-based action selection, or the inference-based decisions, are often modeled with hidden Markov model, we are trying to model the behavior with an artificial network model to predict the role of recurrent neuronal circuits in the behavior. I also plan to introduce our electrophysiology and optogenetics rigs to investigate the neuronal substrate of inference-based decisions.

Session 1 9:35-10:05

[Presenter]
Tomohiko Yoshizawa
Oral Physiology, Department of Oral Functional Science, Faculty of Dental Medicine, Hokkaido University

[Title]
Neural basis of regularity-based reward prediction

[Abstract]
In our daily life, regularity of events is often observed, such as alternate Mondays/weekends etc. Although "alternate", one of the simplest regularity, affects animal's behavior, it has not been well known what neural basis contributes to recognition of the regularity. To address this question, we firstly conducted whole-brain mapping of regions activated by the alternate-reward task in which rats alternately performed reward and no-reward trials. The ^{18}F-fluorodeoxyglucose-positron emission tomography (^{18}F-FDG-PET) revealed that the ventral tegmental area (VTA) was activated by the task. Since the VTA is one of the major sources of dopaminergic neurons encoding the reward-prediction error (RPE), we next recorded neural responses to alternate rewards using the electrophysiological technique, then found two types of RPE-coding neurons; one reflected regularity of alternate rewards and the other entire reward probability. As the VTA neurons mainly project to the dorsomedial striatum (DMS) and the nucleus accumbens (NAc), we finally observed dopamine (DA) dynamics in these areas using the fiber photometry recording of dLight1.1. DA dynamics in the DMS more strongly reflected the regularity of alternate rewards than in the NAc. These results suggests that the VTA→DMS projection is important to recognize regularity of events.

Session 1 10:05-10:25

[Presenter]
Masakazu Taira
OIST

[Title]
Serotonergic control of model-based decision making

[Abstract]
Serotonin (5-HT) is an essential neuromodulator affecting behavioral, affective, and cognitive functions. Recent studies by tryptophan depletion in humans and devaluation paradigm in mice suggest that 5-HT promotes model-based decision making. However, the influence of 5-HT on such decision making remains poorly understood. Recent development of rodent two-step decision making tasks enables us to examine the effect of 5-HT manipulations in situations where rewards do not simply reinforce previous choices but rather interact with task structure to influence policy. Here we took a two-step decision making task and tested the effect of optogenetic inhibition of 5-HT neurons using Tph2-ArchT transgenic mice. We implanted an optic probe above the dorsal raphe nucleus (DRN) and applied photoinhibition by yellow light from outcome delivery to first-step choice at the next trial. In control trials, blue light stimulation was applied. Mice showed choice behavior using model-based controls. The photoinhibition shortened the time to make first-step choices, possibly due to disrupted deliberative model-based decision making process. Furthermore, fitting model-free/model-based hybrid reinforcement learning model suggested that photoinhibition decreased the reliance on model-based decision making. These results revealed the computational role of DRN 5-HT neurons in model-based decision making in dynamic environments.

Session 1 10:25-10:45

[Presenter]
Yukako Yamane
OIST

[Title]
Calcium imaging data analyses --- practice and tools

[abstract]
I will talk about two topics we are working on for the Brain/Mind project (https://brainminds.jp/en/).
1. OptiNiSt (Optical neuroimage studio)
A common problem in optical neuro-imaging research is handling huge image data efficiently and reliably to deliver scientific discoveries and open them to the community for further analyses. Numbers of Ca++ imaging data-processing software tools are becoming available in open sources, such as CaImAn and Suite2P. However, selecting and combining those tools to set up a coherent data processing pipeline is a common issue for researchers. OptiNiSt helps researchers try multiple data analysis methods, visualize the results, and construct data analysis pipelines that can be run on GPUs or HPC clusters for efficient processing.

2. Data analysis of wide-field calcium imaging of marmoset during a two-target reaching task
The causal relation of neural activity is the key to understanding the complex neural network. I will show an analysis example of wide field imaging data. The wide-field calcium imaging data was reduced its dimension by non-negative matrix factorization. Causal relations of resulting activity components were examined using convergence cross mapping. Convergence cross mapping is based on non-parametric modeling of dynamic systems. The result showed some focal areas, such as parietal or primary motor areas, that have a causal effect from many other areas.

Session 2 11:00-11:30

[Presenter]
Jun Igarashi
RIKEN

[Title]
Toward mammalian whole brain-simulations: A parallel computing of a model of the cerebral cortex, cerebellum, and thalamus on the supercomputer and analysis on spatial features of the human macroscopic connectome

[Abstract]
A whole mammalian brain simulation is expected to be the ultimate approach to investigating interactions among huge numbers of neurons. However, it has been difficult to realize it due to limitations to computational resources and parallel computing methods for simulation and difficulty to measure connections and neural activities in physiological experiments.

To overcome these problems, we have been studying 1) how to realize an efficient parallel computing of large-scale brain simulation on supercomputers and 2) how to get the necessary information from the connectome for modeling. In this talk, we will introduce our research activities to solve the problems.

First, we will present large-scale brain simulations utilizing the supercomputer Fugaku having a single-precision performance of about one exaFLOPS. We developed a new data structure for MONET to utilize the wide vector units of Fugaku. We used it with the previously proposed parallel computing method that combines a tile partitioning method of neural networks and a communication method to reduce communication frequency and time using minimum signal transmission delay. We tested it for a spiking neural network model consisting of the cerebral cortex, cerebellum, and thalamus (CCT) on Fugaku. The new MONET simulated CCT with 94 billion neurons for one second of biological time with 15 seconds of elapsed time using 150 thousand compute nodes of Fugaku. The results suggest that the proposed method would enable mammalian whole-brain simulations on exascale supercomputers.

Second, we will present an analysis of spatial features of the human macroscopic connectome. Spatial features, such as topography and divergence/convergence, reflect the information processing mechanism, which is crucial for understanding and modeling the brain. However, it has not been comprehensively investigated. We analyzed the spatial features using diffusion magnetic resonance imaging data of one entire hemisphere of the human cerebral cortex. The early sensory areas, which are located far from the center of the cerebral cortex, exhibited high topography and low divergence/convergence in the connectivity. On the other hand, the limbic system, which tends to be located near the center of the cerebral cortex, showed high divergence/convergence and low topography in the connectivity. These results suggest that topography and divergence/convergence are organized over the cerebral cortex to balance energy efficiency and performance.

Session 2 11:30-12:00

[Presenter]
Carlos Enrique Gutierrez
Softbank

[Title]
A collaborative framework for brain modeling

[Abstract]
Brain modeling requires the incorporation of anatomical, morphological and physiological features, among other experimental data for biologically constraining models. The passage from raw data to model requires data identification, integration and transfer functions. Moreover, executable code generation for simulations at several scales should be provided for easily testing different specifications without the need of programming.

We introduce SNNbuilder, a spiking neural network model builder for systematic and incremental data-to-model generation. We created a generic database, GUI web-interfaces, a code generator and a simulation manager for collaborative modeling of the brain and opened the framework publicly in a web server.

In addition, we discuss future features, integration with other tools and standards, and explore opportunities to provide on-line brain-simulations for testing hypothesis and making predictions.

Session 2 12:00-12:20

[Presenter]
Sergio Verduzco
OIST

[Title]
In search of biological hierarchical reinforcement learning

[Abstract]
Reinforcement learning is one of the most successful machine learning techniques, but using it to control an embodied agent in continuous time and space can be very challenging. One reason is the combinatorial explosion of states and policies. A second reason is that rewards may happen as the result of actions far in the past. Hierarchical architectures hold the promise of taming the combinatorial explosion, but for this they may need to learn representations of the variables to be controlled at each level. Working memory has the potential to solve the temporal credit assignment problem, but only if the information to be remembered is appropriately chosen. I will describe how, using the basic components of the mammalian nervous system, we are attempting to put together the ingredients of hierarchical reinforcement learning: representation, prediction, memory, and control.

Session 2 12:20-12:40

[Presenter]
Makoto Otsuka
LiLz Inc.

[Title]
Building a Startup in Okinawa

[Abstract]
LiLz Inc. is a small startup company in Okinawa founded in 2017. The mission of our company is to solve real-world problems using hardware and software. Recently, our service called LiLz Gauge, an ML-equipped cloud service for remote inspection, and our hardware called LiLz Cam, a battery-powered IoT camera with long battery life, have attracted attention in a market of facility management and beyond. In this talk, I will talk about a brief history of LiLz and its future perspective from the viewpoint of its founder.

Session 3 14:00-14:30

[Presenter]
Junichiro Yoshimoto
NAIST

[Title]
Modeling Heterogeneous Brain Dynamics of Depression and Melancholia Using Energy Landscape Analysis

[Abstract]
Our current understanding of melancholic depression is shaped by its position in the depression spectrum. The lack of consensus on how it should be treated - whether as a subtype of depression, or as a distinct disorder altogether - interferes with the recovery of suffering patients. In this study, we analyzed brain state energy landscape models of melancholic depression, in contrast to healthy and non-melancholic energy landscapes. Our analyses showed significant group differences on basin energy, basin frequency, and transition dynamics in several functional brain networks such as basal ganglia, dorsal default mode, and left executive control networks. Furthermore, we found evidences suggesting the connection between energy landscape characteristics (basin characteristics) and depressive symptom scores (BDI-II and SHAPS). These results indicate that melancholic depression is distinguishable from its non-melancholic counterpart, not only in terms of depression severity, but also in brain dynamics.

Session 3 14:30-15:00

[Presenter]
Tomoki Tokuda
ATR

[Title]
Multiple clustering based on Wishart mixture models and its application to psychiatric data

[Abstract]
In this talk, I ciscuss a novel multiple clustering method based on Wishart mixture models. This method was developed to identify multiple clustering patterns of objects that are featured by correlation matrices without vectorization (i.e., preserving the correlation matrix structure of data). Using this method for functional connectivity data from functional MRI, one can identify the underlying pairs of associations between a subject cluster pattern and a brain sub-network. We applied this method to SRPBS (Strategic Research Program for Brain Sciences) data consisting of various psychiatric disorders. As a result, we identified four subject clusters, which were characterized by major depressive disorder, young healthy control, schizophrenia/bipolar disorder and autism spectrum disorder with the relevant brain subnetwork of cerebellum-thalamus-pallidum-temporal. These clustering results were largely validated by independent datasets. This result suggests that the aforementioned subnetwork may discriminate between different psychiatric disorders, which provides a possible framework for spectrum understanding of psychiatric disorders.

Session 3 15:00-15:20

[Presenter]
Alan Fermin
Hiroshima University

[Title]
Neuroanatomical abnormalities and interoceptive disturbances in depression

[Abstract]
In the cerebral cortex, the insula is one of a few targets that receives massive interoceptive information from multiple visceral systems. The insula's unique modular cytoarchitecture and hierarchical organization suggests a specialization for the processing of interoceptive information.
In this talk, I will briefly introduce our Insula Hierarchical Modular Adaptive Interoception Control (IMAC) model, which was inspired by Doya's now classic 1999 Neural Networks paper.
Finally, I will present our neuroanatomical findings showing how the reduced gray matter volumes of several brain regions involved in interoceptive information processing can account for parasympathetic cardiovascular disturbances observed in patients with depression.

Session 3 15:20-15:40

[Presenter]
Yu Shimzu
Aikomi

[Title]
Digital Therapy for People with Dementia and their Caregivers

[Abstract]
More than 55 million people live with dementia worldwide and with the proportion of older people in the population increasing, this number is expected to rise to 78 million in 2030.
Unlike many people assume, dementia does not only affect memory, but also cognitive functions such as orientation and decision making and isaccompanied by changes in mood, emotional control, behaviour, or motivation. The absence of treatment has therefore a huge impacts for the people living with dementia, their carers, families and society at large, even sparking human rights discussions.

As a medical cure can not be expected soon, Nick Hird and Junichi Kato founded Aikomi (www.aikomi.co.jp) to tackle the burden of dementia from a different angle: with an AI driven digital therapy based on the three pillars of person centered care, five sense stimulation and communication.

In 2020, I joined them in the 3rd year of company establishment as CTO and their first full time employee. Since then, we have grown to a team of 12 with our first preliminary product ready to commercialize last February (www.aikomicare.com). Hear about our vision, our ideas on how to realize it, the journey we have come so far and the journey that still lies before us.

Session 4 16:00-16:30

[Presenter]
Makoto Ito
LiNKX Inc.

[Title]
Activities to implement modern technologies into society
-- AI, robots, web development technology, etc. –

[Abstract]
Currently, many advanced technologies are being developed, such as deep learning, collaborative robotics, web development technology, etc. We consider that these technologies will be able to produce more valuable services when used in combination rather than in isolation. Since LiNKX has a wide range of engineers, we are able to create services that integrate these different technologies.
This time, I'd like to introduce three of our activities. One is a navigation system for blind people in the subway (ShikAI), the other is a robot that puts twelve beer cans into a case (box packing robot), and the third is a laboratory automation system that aims to automate research and development sites (Digital lab).

Session 4 17:00-17:20

[Presenter]
Hiroaki Hamada
Araya

[Title]
Curiosity as information search: Toward model-based curiosity

[Abstract]
Curiosity is a motivational driver for exploratory behaviors, which are the key to our creative cultures. A theory hypothesized that curiosity is associated with two different information processing: information sampling and information search. Information sampling is to explore the uncertainty of choices, and information search is to explore unknown information. Multiple studies worked on the neural processing of information sampling. Neural processing of information search, however, remains unclear. In this talk, I will mainly present my recent work on curiosity as information search. I performed a behavioral fMRI experiment to identify neural correlates of information search based on learning progress signals. Our preliminary results imply different neural processing for accuracy and learning progress. Finally, I will propose the next target of curiosity studies, model-based curiosity.

Session 4 17:20-17:40

[Presenter]
Kenji Doya
OIST

[Title]
Next 10 years of Neural Computation Unit Kenji Doya

[Abstract]
Neural Computation Unit started in April 2004 as a part of Initial Research Project for OIST. In the last nearly 18 years, our challenges have lead to exciting new discoveries, such as that robots can evolve their own rewards, how the brain realizes reinforcement learning and Bayesian inference, and that serotonin promotes patience and model-based decision making.

As I turned 60 years old and the OIST retirement is 70 years old, our unit has 10 years to go from now. Then what should we work on in the coming years? I have some ideas but hope to exchange thoughts and dreams with all participants.