Session 1　9:30 – 10:00

[Presenter]
Makoto Ito
Progress Technology Inc.

[Title]
Industrial Use of Machine Learning

[Abstract]
Conventional high-power industrial robots must be separated from people's working space with fences. However, a "collaborative robot" that meets certain safety standards, it is legally permitted to work with people. Collaborative robots have been introduced in various industries such as food industry, electronic parts industry, automobile industry, etc., and are used in various applications such as pick & place, quality inspection, assembly.

Our New Development Division began business in 2017 to introduce systems using collaborative robots according to customer's needs. Our strength is that we can incorporate not only image-processing techniques such as, color detection, and template matching, but also, machine-learning techniques, such as, regression model, support vector machine, deep learning (classification, object detection, semantic segmentation). Today, I introduce various case examples.

Session 1　10:00 – 10:30

[Presenter]
Tomohiko Yoshizawa
Tamagawa University

[Title]
Neural basis of regularity/irregularity cognition during the alternate-random reward task

[Abstract]
In our daily life, regularity of events often is observed, such as alternate Mondays/weekends etc. "Alternate", one of the simplest regularity, does not only affect animal's behavior but also neuronal activity. Isomura and his colleagues have shown that rats successfully understood the alternate-reward rule in the forelimb movement task and that their striatal neuronal activities were modulated by reward expectation [1]. However, the underlying neural implementation of this process is still not comprehensively understood. Therefore, our questions in this study are as follows;
1) Can animals find regularity/irregularity of events when sensory inputs and motor outputs are unchanged?
2) What neural mechanisms process regularity/irregularity under such a situation?
For the first question, we have developed a novel regularity/irregularity-detecting task with unchanged sensory inputs and motor outputs (Alternate-random reward task). In each trial, rats should push a spout-lever and hold it until presentation of go-cue. If they pull it immediately after the go-cue, they can get two drops of water on 50% probability. In the alternate-reward block, reward and no-reward trials are presented alternately. In the random-reward block, reward or no-reward trial is randomly presented in each trial. Under the alternate-reward rule, rat's forelimb behavior was more strongly affected by the last reward experience than under the random-reward rule. Thus, rats successfully understood nature of regularity/irregularity of reward. Using this behavioral task, we are currently trying pathway-specific neuronal recording using the Multi-Linc (Multi-areal/Multi-neuronal light-induced collision) method [2] to identify which neural circuits are associated with the regularity/irregularity.

[References]
[1] Isomura *et al.*, Reward-Modulated Motor Information in Identified Striatum Neurons, *The Journal of Neuroscience*, 2013.
[2] Saiki, *et al.*, In Vivo Spiking Dynamics of Intra- and Extratelencephalic Projection Neurons in Rat Motor Cortex, *Cerebral Cortex*, 2017

Session 2　11:10 – 11:40

[Presetner]
Tomoki Tokuda
NARA Institute of Science and Technology

[Title]
Predictions of depression and earthquake by means of statistical methods

[Abstract]
In this talk, I present two studies for statistical prediction, which I have recently been engaged in. First, prediction of depressive disorder. Early detection and intervention of depression are important for effective treatment. However, a patient tends not to be aware of the disease, which delays going to hospital. I discuss how a supervised statistical model can be used for early warning of depressive disorder based on monitoring one's daily activities. Second, prediction of a large earthquake. A short-term prediction of a large earthquake is considerably important, yet quite challenging. Shortage of scientific data in such rare events hinders supervised learning of the prediction model. Nonetheless, a specific precursor event that uniquely occurs prior to a large earthquake, is quite helpful for such a prediction. I discuss a possible precursor event of the 2011 Great Tohoku Earthquake, which has been identified by means of cluster analysis.

Session 2　11:40 – 12:10

[Presenter]
Junichiro Yoshimoto
NARA Institute of Science and Technology

[Title]
Statistical analysis on characteristic whisker movements of mice observed in reward anticipation and acquisition

[Abstract]
Internal states of the brain can be often reflected as facial expressions. However, how animals show their facial expression is largely unexplored. Here we investigate whether a whisker of mice might convey some information of their internal states related to reward processing. We trained three mice for an auditory Go/No-Go task and filmed a whisker during task performance after the mice learned the task. We found that approximately 5-8 Hz periodic whisking was commonly observed during reward-associated “Go" cue presentation. Such whisking rarely occurred in "No-Go” trials or in “Go" trials where the mice were not motivated to get a reward. Furthermore, after acquiring a reward, the mice whisked with a more protracted set-point. Using machine learning, we obtained a computer algorithm that could accurately indicate reward-anticipating and reward-acquiring trials only from whisker time plots. Our analyses suggest that mice exhibit stereotypic whisker movements as a part of orofacial movements related to reward anticipation and acquisition.
This study was conducted as part of collaborative research with Prof. Takayuki Yamashita at Nagoya University, who also used to be a researcher at OIST.

Session 2　12:10 – 12:30

[Presenter]
Yukako Yamane

[Title]
Study of activity of ventral visual neurons toward natural vision.

[Abstract]
1) Saccade order dependent firing rate modulation of neurons in macaque visual area during free viewing.
Animals actively sense their surrounding environment. Primates frequently move their eyes during visual scene recognition. In such an active situation, their eye movement pattern can affect sensory processing. One mechanism involves the possibility that the activity is modulated across the history of fixated objects. Here, we examined the visual neuronal activity during free viewing, and whether they exhibit different properties depending on the order of fixations. We found the reduction of firing rate of individual neuron across order of fixations. I discuss this effect in relation to object selectivity of individual and population neuronal activity.

2) Population coding of figure ground of natural image in macaque V4 neurons.
Segmentation of a natural scene into objects and background is a fundamental but challenging task for understanding the scene. We examined activities of a population of macaque V4 neurons while natural image patches were presented. The natural image patches were optimized for including a variety of local stimulus characteristics.
Individual neurons showed low consistency across the image patches, indicating that single neurons were not capable of correctly signaling figures and grounds. We examined whether neurons as a population has an ability to discriminate figure ground using support vector machine The integration of the activities of a few tens of neurons yielded discrimination accuracy far greater than that of single neurons, suggesting the crucial role of population coding for figure-ground discrimination in natural images.

Session 3　14:00 – 14:30

[Presenter]
Stefan Elfwing
ATR

[Title]
Online adaptation of meta-parameters and automatic constructions of reward functions in reinforcement learning.

[Abstract]
Neural network based reinforcement learning (RL) has gained a lot of attraction in recent years, because of very successful applications in video games, such as Atari 2600 games, and in board games, such as Go.
The performance and efficiency of RL depend critically on a few meta-parameters, which modulate the learning updates and the trade-off between exploration and exploitation, and the reward function, which defines the goal of the task for the agent.

Session 3　14:30 – 14:50

[Presenter]
Paavo Parmas

[Title]
Model-based reinforcement learning by differentiating particle samples

[Abstract]
Optimizing a behavior by backpropagation through simulations with a learned model of the environment is an attractive concept; however, the idea has found limited success. I will explain that one reason for this are ill-behaved gradients caused by chaotic properties of long chains of computations---a similar concept to the exploding gradient problem in deep learning. I then show that I can overcome such issues with a new total propagation algorithm, which is a clever algorithm for combining gradient estimators during the backward pass, and it can effectively estimate gradients even when backpropagation gradients are ill-behaved.

Session 3　14:50 – 15:20

[Presenter]
Jiexin Wang
ATR

[Title]
Multiple deep reinforcement learners from reward and punishment for robot navigation

[Abstract]
The Maxpain architecture learning reward and punishment in parallel showed advances than learning only a single reward with positive and negative signals, in terms of learning efficiency and safety. On the other hand, the CRAIL (cooperative and competitive reinforcement and imitation learning) framework learning multiple heterogeneous modules concurrently considered attributing the advantage of each module in different learning stages into one mixture policy. In this work we propose multiple reinforcement learners to unify this two ideas. We treat reward and punishment learners as cooperators in the same signal scales. For a robot navigation task, we utilize multiple learners in different ways of sensor fusion as competitors and cooperators to improve the learning efficiency. The mixed policy weights were determined on a state-value dependent selector as the evaluation of performance during learning.

Session 3 15:20 – 15:40

[Presenter]
Christopher Buckley

[Title]
Smartphone Based Robots for Reinforcement Learning

[Abstract]
Robots have been developed as a tool for various reinforcement learning tasks using a smartphone's processor, camera, accelerometer and gyroscope. The accelerometer and gyroscope data are used to determine the spatial orientation of the robot, namely tilt angle and angular velocity, via sensor fusion. Linear velocities are determined by processing the input from an external quadrature sensor pair built into each wheel. The tilt angle, angular velocity, and wheel speed can be externally read or set via a Java library named abcvlib (Android Bot Computer Vision Library) and used within various controllers as input or feedback parameters.

A brief summary of the past smartphone robot hardware and software, along with the current progress will be presented. A brief overview of a few use-cases for learning will also be given.

Session 4　16:00 – 16:30

[Presenter]
Jun Igarashi
RIKEN

[Title]
Large scale simulation of a cortico-thalamo-cerebellar circuit on K computer.

[Abstract]
Human-scale whole-brain simulations are estimated to realize in the 2020s by using the next-generation of supercomputers. However, it remains unclear how we should parallelize the whole brain model for efficient calculation.
To investigate it, we focused on the cortico-thalamo-cerebellar circuit because the cortex and cerebellum include 99 % of neurons and synapses in the mammalian brain, which consumes most of the computational resources.
In the current study, we propose a parallelization method using tile partitioning method and communication frequency reduction methods using signal transmission delay. We applied the parallelization method to simulation of a cortico-thalamo-cerebellar circuit on the K computer and tested computational performance.
The proposed method showed good computational performance. The result suggests the parallelization method may work for realizing whole-brain scale simulation on the next-generation supercomputer.

Session 4　16:30 – 16:50

[Presenter]
Hiromichi Tsukada

[Title]
A Study of Data Driven Model using Structural-Functional MRI Data of Common Marmoset Monkeys

[Abstract]
Structural and functional data of common marmosets at different scales are currently being measured and accumulated in the Brain/MINDS project. One approach to find out new knowledge by utilizing these data is producing data-driven computational models and exploring the model parameters to relate structural and functional networks.
Here we constructed a whole brain network model based on the structural connectivity matrix estimated from diffusion-weighted MRI data and examined how the network dynamics can reproduce the functional network observed by resting state fMRI.
We show the results that the balance between local excitatory and inhibitory connections is an important factor in reproducing resting state fMRI data, regarding both mean spatial structures and temporal structure of their changes. We also introduce the methods to compare the resting state dynamics between common marmoset monkey and human brains in MRI.

Session 4　16:50 – 17:10

[Presenter]
Carlos Enrique Gutierrez

[Title]
A spiking neural network model of the whole-brain circuit linking basal ganglia, cerebellum and cortex

[Abstract]
The neural circuit linking the basal ganglia, the cerebellum and the cortex through the thalamus is supposed to play essential roles in motor and cognitive action selection and control. However, how such functions are realized by multiple loop circuits with neurons of multiple types is still unknown. In order to investigate the dynamic nature of the whole-brain network, we built biologically constrained spiking neural network models of the basal ganglia, cerebellum, thalamus, and the cortex and ran an integrated simulation using K supercomputer.
Models correspond to 1x1mm2 of cortical surface and replicate basic functions like resting state. We then increased the number of neurons and cortical surface to 5x5, 7x7, 9x9mm2. We simulated the different scales using NEST 2.16.0, during 1 biological second of time, on the K supercomputer. Simulation used a hybrid parallelization approach and computational efficiency was evaluated in terms of building and simulation time, and memory consumption.
Moreover, we evaluated the model's biological plausibility, particularly the Basal Ganglia (BG) circuit during resting state and action selection functions, and generally the whole-brain resting state. Reproduction of basic functions in a whole-brain model will allow us to gradually study more features, like the closed loop BG-thalamo-cortical dynamics, and reproduce more complex behaviors.

Session 4　17:10 – 17:30

[Presenter]

Kenji Doya

[Title]

Toward Evolutionary and Developmental Intelligence

[Abstract]

Given the phenomenal advances in artificial intelligence in specific domains like visual object recognition and game playing by deep learning, expectations are rising for building artificial general intelligence (AGI) that can flexibly find solutions in unknown task domains. One approach to AGI is to set up a variety of tasks and design AI agents that perform well in many of them, including those the agent faces for the first time. One caveat for such an approach is that the best performing agent may be just a collection of domain-specific AI agents switched for a given domain. Here we propose an alternative approach of focusing on the process of acquisition of intelligence through active interactions in an environment. We call this approach evolutionary and developmental intelligence (EDI). We first review the current status of artificial intelligence, brain-inspired computing and developmental robotics and define the conceptual framework of EDI. We then explore how we can integrate advances in neuroscience, machine learning, and robotics to construct EDI systems and how building such systems can help us understand animal and human intelligence.