Synchronization phenomena on complex networks, from math to experiments
- Special workshop for AIMR Advanced Target Projects -

Date : Monday, July 29, 2019, 13:30–18:20
Venue : TOKYO ELECTRON House of Creativity, 3F, Lecture Theater,
Katahira Campus, Tohoku University.
Access: http://www.tfc.tohoku.ac.jp/about_us/contact_and_access.html

13:30〜14:10

Hideaki Yamamoto (AIMR, Tohoku University)

Engineering network synchrony in cultured cortical neurons using microfabricated scaffolds

In vitro experiments using dissociated neurons play irreplaceable roles in molecular and cellular neuroscience. However, its application in systems-level studies has been limited due to the substantial difference in the network organization from the actual brain, which results in the generation of atypical dynamics consisting of highly synchronous burst firing. In this talk, I will discuss about how surface engineering technology can be employed to prepare guidance cues for the network development of cultured cortical neurons and how modulation of network structure at the mesoscopic scale influences the network synchrony.

14:20〜15:00

Haru Negami (Graduate school of Engineering, The University of Tokyo)

Fatgraph models of protein-ligand complexes and their application to circadian rhythm

Living things evolve and adapt/ maladapt to the environment by gene mutations which cause conformational alternation of proteins. Thus, it is important to elucidate the relationships between the three dimensional structures of proteins and their physiological activities. Here, we focus on the fatgraph model of proteins which is a topological method to understand the three dimensional structure. In this talk, we will show our improved fatgraph model for enzyme-substrate complex and will discuss the effect of mutations on oscillating behavior of circadian clock protein from the perspective of the model.

15:10〜15:50

Theoden I. Netoff (Department of Biomedical Engineering, University of Minnesota)

Desynchronization of pathological oscillations in Parkinson's disease with phasic stimulation

Deep brain stimulation is used to treat advanced stages of Parkinson's disease. It is thought that stimulation may desynchronize pathological neuronal oscillations to treat the disease. Topology of the neuronal networks within the basal ganglia and the dynamics of the neurons may result in this

synchrony. Electrical stimulation can be used to desynchronize the neuronal population. In this talk, I will discuss different methods by which we can desynchronize populations with minimal stimulation energy.

16:00〜16:40

Jun-nosuke Teramae (Graduate School of Informatics, Kyoto University)

Biologically plausible learning based on dual stochasticity of the brain

Neurons and synapses of cortical circuit in vivo continuously show highly stochastic activities with consuming large amount of metabolic energy of the brain even while behavioral responses of animals are highly reproducible and reliable. These stochasticities have been studied independently so far and functional roles of them remain unclear. In this talk, I show that integration of these stochasticities provide us an efficient novel learning algorithm of the neural network that is fully consistent with biological observations of cortical circuit. The obtained algorithm seems as a natural confluence of two representative streams of machine learning, the backpropagation learning and the Bayesian inference, while it overcomes various known limitations of the existing algorithms. Unlike the backpropagation, for instance, the method is applicable to networks with arbitral topologies including recurrent networks, requires one type of computations that can be performed asynchronously and locally, and is free from overfitting. We confirm validity of the algorithm by applying the method to various tasks including supervised and unsupervised learning. An experimentally testable prediction of the model and relationship between the algorithm and the reinforcement learning will also be discussed.

16:50〜17:30

Kiyoshi Kotani (Research Center for Advanced Science and Technology, The University of Tokyo)

Model-based analytical insights for multiscale neuronal oscillations

Local field potential in the brain is organized by interacting neurons and have functional roles in cognition and/or attention. We have developed a framework of multiscale analysis of neuronal network using modified theta model, which possesses voltage-dependent dynamics in an analytically suitable form. Origin of macroscopic oscillation for this model is investigated by introducing their Fokker-Planck equation as well as Ott-Antonsen ansatz. In addition, adjoint equations of macroscopic equations are useful to investigate properties of synchronization in macroscopic scale.

17:40〜18:20

Hayato Chiba (AIMR, Tohoku University)

Dynamics of neuronal oscillations on a random graph

We consider the dynamics of a large population of neurons defined on a random network. Synchronization of firing of neurons is known as the gamma oscillation. In this talk, we show that the gamma oscillation appears/disappears depending on the complexity of the network with the aid of the generalized spectral theory.