【Grant-in-Aid for Transformative Research Areas（B）】

Section IV

Title of Project： Multicellular Neurobiocomputing

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Number of Research Area：21B401 Researcher Number：10552036

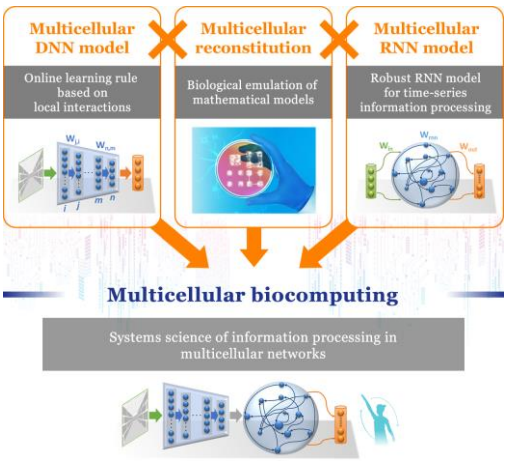
【Purpose of the Research Project】

Digital computers are developed based on the von Neumann architecture, in which the control, computation, and memory units are physically separated. This architecture is fundamentally different from that in the brain, in which an intricate network of nerve cells (neurons) and their spatiotemporal firing patterns govern all the functions. More specifically, information processing in the brain is supported via the manner by which the neuronal network is anatomically organized and specific firing patterns are intrinsically and extrinsically generated. However, its essence still remains shrouded under the veil of "complex systems." To fully elucidate such emergent properties in the brain, this Research Project aims to integrate top-down (the direct measurement of model animal brains) and bottom-up (the manipulative analysis of cultured neural circuits) approaches to build a biologically plausible model for the information processing in multicellular neuronal networks.

【Content of the Research Project】

We focus on sensorimotor control, which is one of the most basic functions embedded in the nervous system of animals, and construct a new "multicellular biocomputing model" that describes the relationship between the collective behavior of biological elements (cells) and their function as a system (brain). Hence, the following three items are investigated:

1. A multicellular deep neural network (DNN) model that performs feature extraction from input data
2. A multicellular recurrent neural network (RNN) model that retains spontaneous activity and transforms the DNN output into a robust multidimensional motor control signal
3. Validation and implementation of the computational model in biological cell.



Overview of the Research Project

The following four research groups ("Planned Research") are organized to promote the project:

- A01 Information and Mathematical Sciences Group: "Information Processing Models and Data Analysis Platforms for Multicellular Neurodynamics" (Leader: KATORI Yuichi, Future University Hakodate)
- A02 Bioengineering Group: "In Vitro Reconstitution of Multicellular Computing Systems" (Leader: YAMAMOTO Hideaki, Tohoku University)
- A03 Molecular and Cellular Physiology Group: "Autonomous and Local Learning Rules in Multicellular Networks" (Leader: MATSUI Teppei, Okayama University)
- A04 Systems Neuroscience Group: "Multicellular Information Representation in the Animal Brains" (Leader: MASAMIZU Yoshito, Doshisha University)

【Expected Research Achievements and Scientific Significance】

A new science of biocomputing resulting in new trends in information science, neuroscience, and medicine is expected to evolve from the Research Area. More specifically, our success will lead to the promotion of a new interdisciplinary field in biocomputing, which involves both microscopic (molecular and cellular) and macroscopic (organism) hierarchies, an architecture for controlling small autonomous robots that integrates sensory information processing and actuator control, the understanding of the neural basis of sensorimotor learning, and advanced therapeutics for injury in the central nervous system.

【Key Words】

Biocomputing: Information processing that is embedded in molecules, cells, or cellular assemblies that constitute living organisms

【Term of Project】 FY2021-2023

【Budget Allocation】 105,000 Thousand Yen

【Homepage Address and Other Contact Information】

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