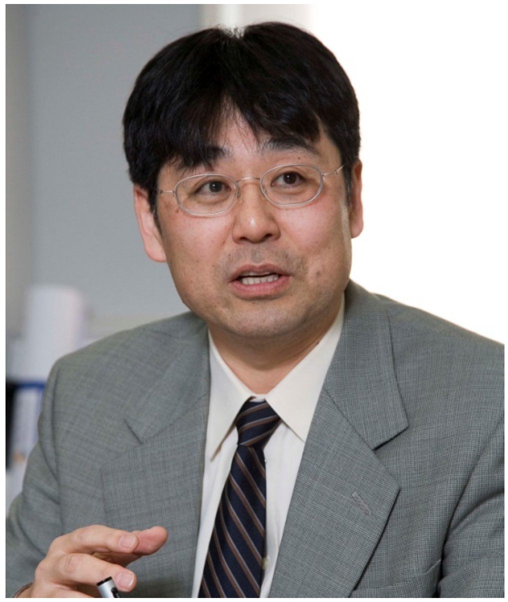
Plenary Talk III

Insect-Machine Hybrid System for Evaluating and Understanding an Adaptive Behavior



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Abstract:

Adaptability, the capability to behave properly in accordance with ceaselessly changing environments, has been required in robotics. Adaptability is an excellent feature of animals, including humans. Insects are the most diverse and abundant animal group representing > 70% of all known animal species. They display a diversity of sophisticated behaviors adapted to their environments by the processing of a simple nervous system, a so-called microbrain system. Insects will become an excellent model for understanding adaptive control in biological systems, which will inspire control and communication in engineered systems.

Adaptive behavior appears in the interaction between a body, brain and the environment. Therefore, an experimental system for evaluating and understanding adaptive behavior requires a closed-loop system in which environmental information is fed back to an insect. This system must be capable of optionally

manipulating the external environment or the properties of the insect, allowing the adaptive behavior to be manipulated. We have developed an insect-controlled robot (or insect-machine hybrid system) that acts based on the behavioral (or the brain/neural) output of an insect, as a novel experimental system that manipulates the interaction between an insect and the real environment in order to evaluate and understand environmental adaptation. The robot measures the behavior of an insect tethered on the robot and moves based on the insect's behavior (or the neural activity of the insect brain). Therefore, it is possible to cause changes in the same way as manipulation of the sensory-motor system of the insect by giving arbitrary manipulation to the motion system of the robot.

We have used a male silkmoth as a robot controller because the moth exhibits a well-defined pheromone searching behavior, the neural basis of which has been well characterized by our group. We evaluated the performance of the robot and analyzed behavioral changes made by the robot when the motion system was manipulated.

First in this lecture, as an example of adaptive behavior of an insect, odor-source orientation behavior and its neural basis will be shown. Second, tests of the feasibility of the behavioral strategy based on the neural system, by implementation in robots, will be shown. Finally, I will demonstrate the insect-machine hybrid system that will lead to great insight for evaluating and understanding adaptive behaviors (or biological intelligence), which will inspire control and communication in engineered systems.

Short Bio:

Ryohei Kanzaki received his B.S., M.S. and D.Sc. degree in Neurobiology from the Institute of Biological Sciences, University of Tsukuba in 1980, 1983 and 1986, respectively. From 1987 to 1990 he was a postdoctoral research fellow at the Arizona Research Laboratories, Division of Neurobiology, University of Arizona. From 1991 to 2003 he was successively an assistant professor, associate professor, and full professor at the Institute of Biological Sciences, University of Tsukuba. From 2004 to 2006 he was a full professor at Department of Mechano-Informatics, Graduate School of Information Science and Technology, The University of Tokyo. Since 2006 he is a full professor at the Research Center for Advanced Science and Technology (RCAST), The University of Tokyo.