Guided self-organization in the real-world machines

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ABSTRACT

Many technologies have evolved through biological inspirations, and we learned that adequate abstraction of mechanisms in nature could give us substantial impacts in the technological development of, for example, control theories, computational algorithms, and advanced mechatronic systems. One of the most significant challenges in bio-inspired robotics is extraction of feasible principles about the real-world self-organization. In the biological world, self-organization processes take place in many different timescales and physical principles. For example, biological systems are made of components that are continuously changing and adapting over different timescales (e.g. evolutionary, developmental and "here and now" timescales), and they rely on a variety of underlying physical principles such as spring-mass-damper and fluidic interactions, cell adhesion, and informational dynamics based on electric signals, most of which are not completely integrated into our robotic systems. In this talk, I introduce our efforts on developing and understanding self-organizing machines in the real world, which are structured into three basic research components. The first research component aims to construct the principles of self-organization through mechanical system-environment interactions such as springy legs interacting with the ground for locomotion purposes. These case studies provide us fundamentals of emergent behaviors because system-environment interactions are the sole basis of self-organization in the real-world. Second, we have been also exploring self-organization of motion control processes, in which we study the underlying mechanisms of sensory-motor calibration of complex musculoskeletal dynamical systems. Together with our collaborating neurophysiologists, we investigate how muscle twitches during sleep could provide basic circuitry for sensory-motor coordination of spinal reflexes. And third, we also investigate the use of soft continuum bodies for next generations of mechatronic systems. Here we make use of thermoplastic adhesive polymers that can be used for soft elastic mechanical bodies as well as dynamic reconfiguration of body shapes and other mechanical properties. Through these case studies of dynamic system-environment interactions, we discuss the implications of our embodiment research with the physical dynamical systems for our comprehensive understanding of guided self-organization and its research directions in the future.

SHORT BIO

Fumiya Iida is an assistant professor for bio-inspired robotics at ETH Zurich since August 2009. He received his bachelor and master degrees in mechanical engineering at Tokyo University of Science (Japan, 1999), and Dr. sc. nat. in Informatics at University of Zurich (2006). In 2004 and 2005, he was also engaged in biomechanics research of human locomotion at Locomotion Laboratory, University of Jena (Germany). From 2006 to 2009, he worked as a postdoctoral associate at the Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology in USA. In 2006, he awarded the Fellowship for Prospective Researchers from the Swiss National Science Foundation, and in 2009, the Swiss National Science Foundation Professorship. His research interest includes biologically inspired robotics, embodied artificial intelligence, and biomechanics, where he was involved in a number of research projects related to dynamic legged locomotion, navigation of autonomous robots, and self-assembling and self-reconfigurable robots.

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