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Title
Body Shapes Brain -- Emergence and Development of Behavior and Mind from Embodied Interaction Dynamics –

Abstract
An ultimate understanding of human cognition and behavior would account for how/why they begin and how/why they develop over the lifetime. Assuming emergence, self-organization and autonomous boot-strap learning, identifying the initial starting set and the principles of their emergence and development would be essential. A constructivist approach assumes the minimal and the simplest set of initial structure and principles, embeds them in realistic circumstances, and lets the entire system evolve under close observation. We believe this is the only plausible approach to the true understanding of human cognition and behavior.

An extremely minimal starting set would be a mere body, without any specific built-in neural functions. Various robotic examples support that even a pure physical body without any computational apparatus exhibits meaningful behavior or information structure (Kuniyoshi et al, 2004).

Then the first principle has to do with exploration and exploitation of a vast variety of possible motion patterns and information structures consistent with the natural body dynamics. We propose “embodiment as a coupled chaotic field” which spontaneously explores and self-sustain such structures (Kuniyoshi&Suzuki, 2004).

Building upon the above principle, we are now constructing a model of early human development incorporating spontaneous exploration and boot-strap learning, leading to open-ended acquisition of versatile flexible motor skills. A model of neuro-musculo-skeletal system is constructed capturing essential features of biological systems: It consists of a skeleton, muscles, spindles, tendon organs, spinal circuits, medullar circuits (neural oscillators), and a basic cortical model (Kuniyoshi & Sangawa, 2006).

A simulation model of a fetus is constructed and placed in a simulated uterus. Also, a model of a neonate is placed on a flat land. The chaotic field principle is naturally embedded in the neural-body dynamics, resulting in spontaneous exploration of a variety of motor patterns. All the neural connections and maps learn while they drive the body. The simulated babies spontaneously discover what it can do with the given bodies, repeat the acquired actions, and the cortical maps are formed accordingly.

The above framework is important because learning about self body may lay the basis for various higher cognitive capabilities, including imitation, object concepts, self/other cognition, and language. And the above model provides a plausible scenario of how the entire development can begin with the minimal starting set, yet progressively approach higher cognition.

References
Yasuo Kuniyoshi is a Professor at the Department of Mechano-Informatics, School of Information Science and Technology, The University of Tokyo, Japan.

He received M.Eng. and Ph.D. degrees in information technology from the University of Tokyo, Japan, in 1988 and 1991, respectively.

From 1991 to 2000, he was a Research Scientist and then a Senior Research Scientist at Electrotechnical Laboratory, AIST, MITI, Japan. From 1996 to 1997 he was a Visiting Scholar at MIT AI Lab. In 2001 he was appointed as an Associate Professor at the University of Tokyo. Since 2005, he is a Professor at the same university.

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Main papers


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