Proposal of Hiroki Mori in ETIS laboratory

Human behavior and cognition emerge out of the structure and dynamics of the brain, body and environment. Considering the origin of human abilities, we should focuses on fetus and infant. What shapes the emergence and development? We assume that the human development is a self-organization process through the movements of the body and sensations from the environment based on the physical structure and dynamics.

Our approach toward this issue was proposed from the perspective of nonlinear oscillators networks that connect to bodies via actuators and sensors. The oscillator activities are shaped not only by the network and body structure, but also by connection the actuators and sensors as interface to the surrounding environment. Based on the approach, we have already constructed a model with Bonhoeffer–van der Pol oscillators, which are connected by Watts and Strogatz network or Barabasi and Albert network, and a snake-like robot as a musculoskeletal system. The model shows the versatile behaviors and dynamic information networks upon the "physical" oscillator network that change depending on the behaviors [1,2].

Although we believe the approach has big potential to reveal the mechanism of emergence of spontaneous behaviors of life, the previous research has some problems as follows. (1) The network of the oscillators and connectivity between the network and the body are randomly connected and analyze the statistics. So we have to conduct a lot of simulations and it is problematic for hardware implementation. (2) The research featured only snake-like robot to analyze the activities easily. (3) The model utilize only muscle length sensors to interact with the body, even though the vision, sound and tactile sensors are useful to recognize the surrounding environments. (4) The simulations of the previous research are not taken into account with the environment.

In this research, we try to handle the above issues. (1) Propose a design principle and a learning method for the network for versatile and adaptive behaviors. (2) Apply the model to our fetus and infant musculoskeletal model and other robot models with a specific body structure. (3) Propose how to connect other sensor modalities. (4) Observe the adaptivity of the model to complex environments in computer simulation and real robots with visual and tactile sensors.

[1] Hiroki Mori, Yuzi Okuyama, and Minoru Asada, "Emergence of diverse behaviors from interactions between nonlinear oscillator complex networks and a musculoskeletal system." In Proceedings of the European Conference on Artificial Life (ECAL 2013), pp.324-331, 2013.
[2] Jihoon Park, Hiroki Mori, and Minoru Asada, "Analysis of causality network from interactions between nonlinear oscillator networks and musculoskeletal system." In Proceedings of the European Conference on Artificial Life (ECAL 2013), pp., 2015.