Research on Neuromorphic Hardware

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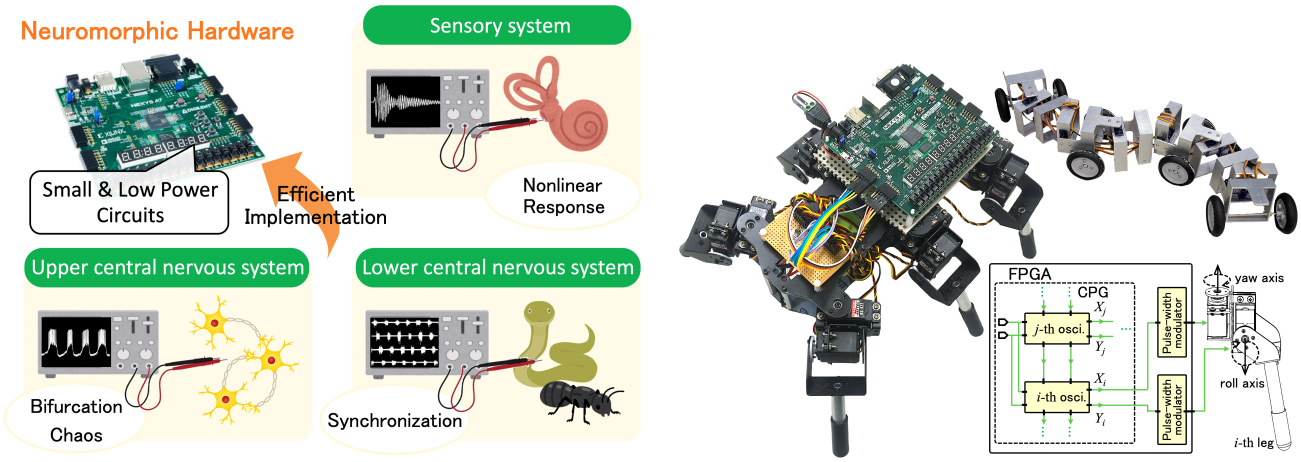
Projects

Neuromorphic engineering is an emerging field that attempts to use electronic circuits to physically mimic biological systems such as the central nervous and sensory systems. These electronic circuits, known as *neuromorphic hardware*, are expected to replace conventional computer architectures. However, biological systems generally exhibit strong nonlinearity, which is challenging to implement in integrated circuits. Therefore, research is needed to investigate circuit implementation methods for designing small and low-power circuits for use in brain-inspired computing devices, bio-inspired robots, and neural prosthetic devices. Our laboratory aims to investigate efficient designs of neuromorphic hardware to mimic these biological systems, in particular presenting hardware-efficient biological system models. Specific research topics we have worked on in the past include as follows: (a) Research on electronic circuit models of neurons and their networks [1, 3], (b) Research on bio-inspired robot gait control circuits [2], and (c) Research on cochlear implants that take into account the nonlinear characteristics of the auditory system [4].



(a) (b)

Figure 1: (a) Conceptual diagram of our research. (b) Application of a central pattern generator model to robot gait control [2]

Selected Papers

[1] Kentaro Takeda and Hiroyuki Torikai, "A novel hardware-oriented recurrent network of asynchronous CA neurons for a neural integrator," *IEEE Transactions on Circuits and Systems II: Express Briefs*, vol. 68, no. 8, pp. 2972–2976, 2021.

[2] Kentaro Takeda and Hiroyuki Torikai, "A Novel Hardware-Efficient Central Pattern Generator Model based on Asynchronous Cellular Automaton Dynamics for Controlling Hexapod Robot," *IEEE Access*, vol. 8, pp. 139609–139624, 2020.

[3] Kentaro Takeda and Hiroyuki Torikai, "A Novel Asynchronous CA Neuron Model: Design of Neuron-like Nonlinear Responses based on Novel Bifurcation Theory of Asynchronous Sequential Logic Circuit," *IEEE Transactions on Circuits and Systems I: Regular Papers*, vol. 67, no. 6, pp. 1989–2001, 2020.

[4] Kentaro Takeda and Hiroyuki Torikai, "A Novel Hardware-Efficient Cochlea Model based on Asynchronous Cellular Automaton Dynamics: Theoretical Analysis and FPGA Implementation," *IEEE Transactions on Circuits and Systems II: Express Briefs*, vol. 64, no. 9, pp. 1107–1111, 2017.