先端科学技術研究科　修士論文要旨

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要旨

Neuromorphic computing, inspired by the dynamics of biological neural systems, has attracted increasing attention for its potential to achieve low power consumption and high-speed processing. Spiking neural networks (SNNs), which transmit information via discrete spikes, are the primary method used in this field. However, there is a trade-off between performance and computational efficiency. In this study, we propose a novel synapse device and an algorithm for efficient image processing using SNNs.

First, we introduce a novel synaptic device, fusion synapse, that consists of a memristor and a capacitor connected in series. By leveraging changes in the time constant as the synapse weight, this proposed synapse enables in-memory computing. On the MNIST handwritten digit dataset, the proposed device achieved a recognition accuracy of 95% at an energy consumption of 640 nJ per inference, surpassing the power efficiency of conventional digital implementations under Denard scaling.

Second, we present a Spiking Locally Competitive Algorithm (S-LCA) for sparse modeling using SNNs. By training via Backpropagation Through Time (BPTT) and the integration of L2 normalization and batch normalization, we reduced the required number of timesteps for convergence from approximately 1000 to just 4. Moreover, the S-LCA demonstrated accuracy comparable to its non-spiking LCA counterpart.

By proposing a novel synaptic device and an advanced training algorithm, this study highlights the potential for high-performance and energy-efficient SNNs in image processing applications.