The world's first demonstration of spintronics-based artificial intelligence

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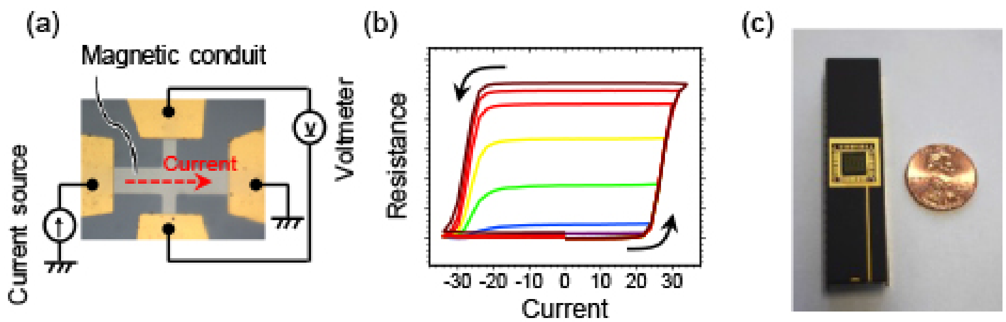

Fig. 1. (a) Optical photograph of a fabricated spintronic device that serves as artificial synapse in the present demonstration. Measurement circuit for the resistance switching is also shown. (b) Measured relation between the resistance of the device and applied current, showing analogue-like resistance variation. (c) Photograph of spintronic device array mounted on a ceramic package, which is used for the developed artificial neural network. Credit: Tohoku University

Researchers at Tohoku University have, for the first time, successfully demonstrated the basic operation of spintronics-based artificial intelligence.

Artificial intelligence, which emulates the information processing function of the brain that can quickly execute complex and complicated tasks such as image recognition and weather prediction, has attracted growing attention and has already been partly put to practical use.

The currently-used artificial intelligence works on the conventional framework of semiconductor-based integrated circuit technology. However, this lacks the compactness and low-power feature of the human brain. To overcome this challenge, the implementation of a single solid-state device that plays the role of a synapse is highly promising.

The Tohoku University research group of Professor Hideo Ohno, Professor Shigeo Sato, Professor Yoshihiko Horio, Associate Professor Shunsuke Fukami and Assistant Professor Hisanao Akima developed an artificial neural network in which their recently-developed spintronic devices, comprising micro-scale magnetic material, are employed (Fig. 1). The used spintronic device is capable of memorizing arbitral values between 0 and 1 in an analogue manner unlike the conventional magnetic devices, and thus perform the learning function, which is served by synapses in the brain.

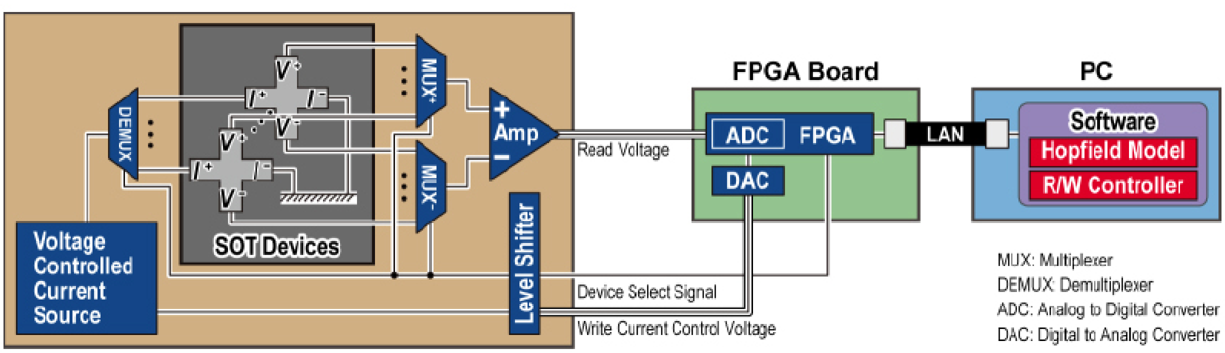

Fig. 2. Block diagram of developed artificial neural network, consisting of PC, FPGA, and array of spintronics (spin-orbit torque; SOT) devices. Credit: Tohoku University

Using the developed network (Fig. 2), the researchers examined an associative memory operation, which is not readily executed by conventional computers. Through the multiple trials, they confirmed that the spintronic devices have a learning ability with which the developed artificial neural network can successfully associate memorized patterns (Fig. 3) from their input noisy versions just like the human brain can.

The proof-of-concept demonstration in this research is expected to open new horizons in artificial intelligence technology - one which is of a compact size, and which simultaneously achieves fast-processing capabilities and ultralow-power consumption. These features should enable the artificial intelligence to be used in a broad range of societal applications such as image/voice recognition, wearable terminals, sensor networks and nursing-care robots.

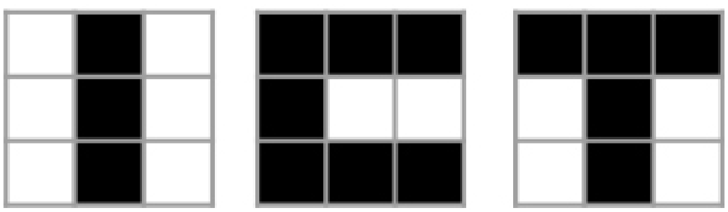

Fig. 3. Three kinds of patterns, "I", "C", and "T", expressed in 3x3 blocks used for the associative memory operation experiment. Credit: Tohoku University

More information: W. A. Borders, et al. Analogue spin-orbit torque device for artificial neural network based associative memory operation. *Applied Physics Express*, DOI: 10.1143/APEX.10.013007

Provided by Tohoku University