Artificial Neural Networks with Spintronics

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Biological neural network consisting of neurons and synapses is a model system of computation when one develops hardware executing complex cognitive tasks that the conventional von Neumann computers cannot readily complete. Here we discuss a spintronics technology to construct artificial neural networks where spintronics devices mimic the function of neurons and synapses. Spintronics devices, namely magnetic tunnel junctions, are critical building block of magnetoresistive random access memory which has been commercialized recently. In addition, recent studies have revealed unexplored functionalities of spintronics devices holding promise for the artificial neural networks [1-5].

In this presentation, we will describe our studies on artificial neural networks based on spintronics technologies. We utilize analog spin-orbit torque devices with an antiferromagnet-ferromagnet bilayer structure as an artificial synapse [6]. We will show a Hopfield-model based associative memory where the capability of supervised learning of the synaptic devices is confirmed [7]. We will also present that the spin-orbit torque switching can reproduce characteristic dynamics of biological synapses and neurons, spike-timing-dependent plasticity and leaky integrate-and-fire, respectively [8], making the systems attractive building blocks for spiking neural network. Mechanism underlying the observed neuron- and synapse-like behavior will be also discussed [9].

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