IIT Bombay makes analog device that mimics neurons

It shows better energy efficiency than digital models

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Manufacturing a brain-like chip made of artificially fabricated neurons is one aim of scientists working in the field of artificial intelligence. There have been some attempts to make this happen. Recently, a team comprising researchers from IIT Bombay and IIT Gandhinagar has succeeded in fabricating an artificial neuron. The work is published in the journal *Scientific Reports*.

This silicon neuron is an analog device that mimics the biological neuron in that it fires a spiky signal when it detects simultaneously occurring inputs from outside. The team tested the neuron by checking whether a network of such neurons can perform select classification tasks. One task it succeeded in was to distinguish between different species of the iris flower – *Iris sentosa*, *Iris virginica* and *Iris versicolor*. The other, more significant, was that it could classify benign and malignant cancers.

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LIF neuron

The schematic of the neuron is as follows: Two so-called pre-neuron drivers are connected to the external circuit, and these feed into two electronic "synapses." These synapses convert the voltage spikes into smooth current variations and feed it into the Leaky Integrate and Fire neuron (LIF neuron) as it is named. In the neuron, the inputs from two synapses are added up by means of a capacitor circuit. As is the nature of the capacitor, when the added current reaches a threshold, the capacitor discharges, giving a means of resetting the current value.

This signal is fed to the "post-neuron driver" which fires when the total current is above a certain value. That is, it fires not at points corresponding to inputs from single synapses, but at points corresponding to signals from both synapses only. This is like how the biological neuron behaves – it ignores isolated inputs and fires when there are simultaneous inputs from many synapses. Like the biological neuron, after firing, it is reset to zero.

"We have only demonstrated the capability of several unit devices [SOI MOSFET] as an efficient analogue to the biological neuron. The challenge remains in the demonstration of complete neural network in hardware where many such neurons will be interconnected and perform some meaningful tasks," says Sangya Dutta a graduate student at the Electrical Engineering Department of IIT Bombay and first author of the paper.

Today, popular search engines are able to recognise voice and images using software implemented on traditional digital server farms that guzzle energy. Comparing this with the device they have developed, Udayan Ganguly of the Electrical Engineering Department of IIT Bombay, in whose lab this research was done, says: "The energy efficiency in biology partly lies in the neurons' ability to code information as tiny 'voltage spike' rather than digital '1' or '0' expressed as high and low voltages. Our silicon-based neuron enables AI tasks with improved energy efficiency compared with digital implementation."

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