Research team building a computer chip based on the human brain

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Today's computing chips are incredibly complex and contain billions of nano-scale transistors, allowing for fast, high-performance computers, pocket-sized smartphones that far outpace early desktop computers, and an explosion in handheld tablets.

Despite their ability to perform thousands of tasks in the blink of an eye, none of these devices even come close to rivaling the computing capabilities of the human brain. At least not yet. But a Boise State University research team could soon change that.

Electrical and computer engineering faculty Elisa Barney Smith, Kris Campbell and Vishal Saxena are joining forces on a project titled "CIF: Small: Realizing Chip-scale Bio-inspired Spiking Neural Networks with Monolithically Integrated Nano-scale Memristors."

Team members are experts in machine learning (artificial intelligence), integrated circuit design and memristor devices. Funded by a three-year, $500,000 National Science Foundation grant, they have taken on the challenge of developing a new kind of computing architecture that works more like a brain than a traditional digital computer.

"By mimicking the brain's billions of interconnections and pattern recognition capabilities, we may ultimately introduce a new paradigm in speed and power, and potentially enable systems that include the ability to learn, adapt and respond to their environment," said Barney Smith, who is the principal investigator on the grant.

The project's success rests on a memristor – a resistor that can be programmed to a new resistance by application of electrical pulses and remembers its new resistance value once the power is removed. Memristors were first hypothesized to exist in 1972 (in conjunction with resistors, capacitors and inductors) but were fully realized as nano-scale devices only in the last decade.

One of the first memristors was built in Campbell's Boise State lab, which has the distinction of being one of only five or six labs worldwide that are up to the task.

The team's research builds on recent work from scientists who have derived mathematical algorithms to explain the electrical interaction between brain synapses and neurons.

"By employing these models in combination with a new device technology that exhibits similar electrical response to the neural synapses, we will design entirely new computing chips that mimic how the brain processes information," said Barney Smith.

Even better, these new chips will consume power at an order of magnitude lower than current computing processors, despite the fact that they match existing chips in physical dimensions. This will open the door for ultra low-power electronics intended for applications with scarce energy resources, such as in space, environmental sensors or biomedical implants.

Once the team has successfully built an artificial neural network, they will look to engage neurobiologists in parallel to what they are doing now. A proposal for that could be written in the coming year.

Barney Smith said they hope to send the first of the new neuron chips out for fabrication within weeks.

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