# Cat brain: A step toward the electronic equivalent

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A cat can recognize a face faster and more efficiently than a supercomputer. That's one reason a feline brain is the model for a biologically-inspired computer project involving the University of Michigan.

U-M computer engineer Wei Lu has taken a step toward developing this revolutionary type of machine that could be capable of learning and recognizing, as well as making more complex decisions and performing more tasks simultaneously than conventional computers can.

Lu previously built a "memristor," a device that replaces a traditional transistor and acts like a biological synapse, remembering past voltages it was subjected to. Now, he has demonstrated that this memristor can

connect conventional circuits and support a process that is the basis for memory and learning in biological systems.

A paper on the research is published online in Nano Letters and is scheduled to appear in the forthcoming April edition of the journal.

"We are building a computer in the same way that nature builds a brain," said Lu, an assistant professor in the U-M Department of Electrical Engineering and Computer Science. "The idea is to use a completely different paradigm compared to conventional computers. The cat brain sets a realistic goal because it is much simpler than a human brain but still extremely difficult to replicate in complexity and efficiency."

Today's most sophisticated supercomputer can accomplish certain tasks with the brain functionality of a cat, but it's a massive machine with more than 140,000 central processing units and a dedicated power supply. And it still performs 83 times slower than a cat's brain, Lu wrote in his paper.

In a mammal's brain, neurons are connected to each other by synapses, which act as reconfigurable switches that can form pathways linking thousands of neurons. Most importantly, synapses remember these pathways based on the strength and timing of electrical signals generated by the neurons.

In a conventional computer, logic and memory functions are located at different parts of the circuit and each computing unit is only connected to a handful of neighbors in the circuit. As a result, conventional computers execute code in a linear fashion, line by line, Lu said. They are excellent at performing relatively simple tasks with limited variables.

But a brain can perform many operations simultaneously, or in parallel. That's how we can recognize a face in an instant, but even a

supercomputer would take much, much longer and consume much more energy in doing so.

So far, Lu has connected two electronic circuits with one memristor. He has demonstrated that this system is capable of a memory and learning process called "spike timing dependent plasticity." This type of plasticity refers to the ability of connections between neurons to become stronger based on when they are stimulated in relation to each other. Spike timing dependent plasticity is thought to be the basis for memory and learning in mammalian brains.

"We show that we can use voltage timing to gradually increase or decrease the electrical conductance in this memristor-based system. In our brains, similar changes in synapse conductance essentially give rise to long term memory," Lu said.

The next step is to build a larger system, Lu said. His goal is achieve the sophistication of a supercomputer in a machine the size of a two-liter beverage container. That could be several years away.

Lu said an electronic analog of a cat brain would be able to think intelligently at the cat level. For example, if the task were to find the shortest route from the front door to the sofa in a house full of furniture, and the computer knows only the shape of the sofa, a conventional machine could accomplish this. But if you moved the sofa, it wouldn't realize the adjustment and find a new path. That's what engineers hope the cat brain computer would be capable of. The project's major funder, the Defense Advanced Research Projects Agency, isn't interested in sofas. But this illustrates the type of learning the machine is being designed for.

**More information:** Full text of paper: pubs.acs.org/doi/full/10.1021/nl904092h

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