Cognitive computing: Building a machine that can learn from experience

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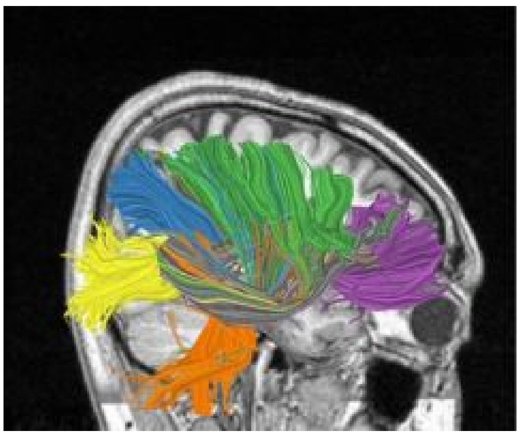

Scientists are studying complex wiring of the brain to build the computer of the future, one that combines the brain's abilities for sensation, perception, action, interaction and cognition and its low power consumption and compact size. Understanding the process behind these seemingly effortless feats of the human brain and creating a computational theory based on it remains one of the biggest challenges for computer scientists. Illustration by: D. Modha, IBM

(PhysOrg.com) -- Suppose you want to build a computer that operates like the brain of a mammal. How hard could it be? After all, there are supercomputers that can decode the human genome, play chess and calculate prime numbers out to 13 million digits.

But University of Wisconsin-Madison research psychiatrist Giulio Tononi, who was recently selected to take part in the creation of a "cognitive computer," says the goal of building a computer as quick and flexible as a small mammalian brain is more daunting than it sounds.

Tononi, professor of psychiatry at the UW-Madison School of Medicine and Public Health and an internationally known expert on consciousness, is part of a team of collaborators from top institutions who have been awarded a $4.9 million grant from the Defense Advanced Research Projects Agency (DARPA) for the first phase of DARPA's Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) project.

Tononi and scientists from Columbia University and IBM will work on the "software" for the thinking computer, while nanotechnology and supercomputing experts from Cornell, Stanford and the University of California-Merced will create the "hardware." Dharmendra Modha of IBM is the principal investigator.

The idea is to create a computer capable of sorting through multiple streams of changing data, to look for patterns and make logical decisions.

There's another requirement: The finished cognitive computer should be as small as a the brain of a small mammal and use as little power as a 100-watt light bulb. It's a major challenge. But it's what our brains do every day.

"Our brains can do it, so we have proof that it is possible," says Tononi. "What our brains are good at is being flexible, learning from experience and adapting to different situations."

While the project will take its inspiration from the brain's architecture and function, Tononi says it isn't possible or even desirable to recreate the entire structure of the brain down to the level of the individual synapse.

"A lot of the work will be to determine what kinds of neurons are crucial and which ones we can do without," he says.

It all comes down to an understanding of what is necessary for teaching an artificial brain to reason and learn from experience.

"Value systems or reward systems are important aspects," he said. "Learning is crucial because it needs to learn from experience just like we do."

So a system modeled after the neurons that release neuromodulators could be important. For example, neurons in the brain stem flood the brain with a neurotransmitter during times of sudden stress, signaling the "fight-or flight" response.

"Every neuron in the brain knows that something has changed," Tononi explains. "It tells the brain, 'I got burned, and if you want to change, this is the time to do it.'"

Thus, a cat landing on a hot stovetop not only jumps off immediately, it learns not to do that again.

Tononi says the ideal artificial brain will need to be plastic, meaning it is capable of changing as it learns from experience. The design will likely convey information using electrical impulses modeled on the spiking neurons found in mammal brains. And advances in nanotechnology should allow a small artificial brain to contain as many artificial neurons as a small mammal brain.

It won't be an easy task, says Tononi, a veteran of earlier efforts to create cognitive computers. Even the brains of the smallest mammals are quite impressive when you consider what tasks they perform with a relatively small volume and energy input.

"I would be happy to create a mouse brain," Tononi says. "A mouse brain is quite remarkable. And from there, it shouldn't be too hard to scale up to a rat brain, and then a cat or monkey brain."

Provided by University of Wisconsin-Madison

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