Improving Cognition in Computers

Scientists are studying how to design circuits that can recognize objects like people can

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By Marlene Cimons, *National Science Foundation*

A computer probably can calculate the answer to a math problem much faster than the average person. But when it comes to visual recognition—faces, objects, and patterns—the human brain has it all over even the most sophisticated processors.

"Humans and other primates have the remarkable ability to effortlessly recognize things visually,'' said Gabriel Kreiman. '' Currently, no computer can recognize objects to the level that humans can. Humans do it without even thinking about it. But there is very complex machinery behind the recognition process.''

Kreiman, a professor in the department of neuroscience and ophthalmology at Harvard Medical School and Children's Hospital in Boston, is trying to understand the neural underpinnings of human brain function with the goal of designing computers that ultimately can recognize objects as rapidly and accurately as people.

"It would be very useful to build computers that could rapidly recognize objects,'' he said. "There would be many important applications: recognizing humans at ATMs, for example, terrorists at airports, and especially patterns and images for clinicians, such as abnormalities in sleep patterns, tumors, cell type patterns—all the patterns that clinicians need to look for on a daily basis. It could help clinicians tremendously if we could help them by providing an automatic way of visually recognizing patterns.''

The research is funded by a $503,398 grant from the National Science Foundation as part of the American Recovery and Reinvestment Act of 2009. The work has considerable potential in the fields of engineering and computing, as well as practical impacts on such areas as health care and security.

"The long term goal is to build a computational circuit inspired by the human brain that can function independent of humans,'' Kreiman said. "In between, there might be hybrid approaches, with humans working together with computers.''

Human beings have the ability to perceive stimuli, experience emotions and reflect about others and themselves, he said.

"At the heart of these and other capabilities is the phenomenon of consciousness,'' he said. "Consciousness has to be implemented through the hardware of neurons in our brains. Somehow, a physical system composed of neuronal circuits gives rise to what seems to be the least physical properties of all: our thoughts and feelings. How this transformation takes place has preoccupied generations of scientists and philosophers.''

Fortunately, advances during the last several decades have made it possible to investigate the mechanisms of consciousness scientifically.

Kreiman is studying the brain function of patients, both adults and children, who already have electrodes implanted in their brains for medical reasons, usually for epilepsy, to help control seizures.

“We monitor the activity inside the human brain at very high spatial and temporal resolution; essentially we look at the behavior of neurons at the level of milliseconds,’’ he said. “We go in with a laptop and show them images. We ask them to perform different kinds of tasks, to play games, to recognize images. The activity from the patients’ neurons goes to our computers, and we can correlate that information with the images they have seen.’’

Despite the amazing contributions computers provide, there are lots of things that humans still can do better than machines, Kreiman said.

“We don’t really think about them because they are so trivial to us,’’ he said. “In addition to seeing, just the simple process of walking remains a very challenging task for robots--to navigate and recognize obstacles, to adjust your posture and force to different types of terrains, slopes and so forth.”

Moreover, scientists have yet to devote efforts into defining the brain circuits responsible for emotions, and translating those circuits into computers, Kreiman said. In the future, computers may be able to read, as well as convey, emotions, he said.

“Computers are poor at mostly everything that has to do with common sense,’’ he added. “They are good at everything where there is a clear defined mathematical algorithm, for example, computing the square root of seven--a computer can do it in a fraction of a millisecond. You can recognize whether the person standing in front of you is happy or sad. A human can look at the person, recognize her as a friend, and see that she is sad today. Currently, there is no computer that can come close to that.’’

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