CARL and the Brain >>

BRANDON WONG | Staff Photographer
CARL moves between different squares of light on the floor. He is trained to avoid certain squares.

Jeffrey Krichmar, associate professor in Cognitive Science, and Brian Cox, senior development engineer in the same department, have constructed a robot with mouse ears and a sophisticated, adaptive computer brain named CARL (after the Cognitive Anteater Robotics Laboratory).

“We made — Brian and I — mathematical models of how the brain works, put it on the computer, and hooked it up to a robot … that can interact with the world,” Krichmar said of CARL.

CARL’s mousey look — with whiskers and a tail to match the ears — are a nod to the origins of his unique brain, a series of tests of rats run by UCSD scientists Andrea Chiba, Douglas Nitz and Angela Yu in collaboration with Krichmar and Cox.

The rats used in these tests were trained to seek out flashing lights in the UCSD laboratory arena, and if the rodent found the bulb that had been lit, he was given a Honey Nut Cheerio in reward.

“What we measure is how [the rat] orients himself in the center, so that his nose faces directly the most likely [light to be lit],” Douglas Nitz said, the lead scientist of the project at UCSD.

The researchers created variations of that test in order to measure activity in two brain systems dealing with attention and uncertainty.

“We’re [using the UCSD group’s] behavior data to make CARL do the same exact thing [as the rats in testing], but we can do what they can’t, which is record CARL’s brain. We can make inferences on what’s going on in a real brain by looking at CARL’s,” Krichmar said.

Krichmar and Cox run CARL through virtual mazes and learning activities on a floor of 25 tiles that light up in red, green, blue and magenta. As the lights change and move, the robot roves around the area, looking for green tiles (which he has learned are good), avoiding red tiles (which he has learned are bad), and ignoring blue and magenta tiles in the search.

“What makes him special is that he’s getting these signals of good and bad [from the computer that houses his brain], and it’s really causing him to focus his attention … his brain turns on to everything important,” Krichmar said. Previous models Cox and Krichmar constructed were unable to focus as well in a noisy, busy atmosphere like that of the real world.

The robot demonstrates a certain personality in his wandering of the room that Krichmar quickly noted.

“If you look at a rat, and the way it gets around the world, [CARL] is far better than any robot out there. I think, following this model, we can maybe make some advances for robot control in general,” Krichmar said.

If it is a revolutionary robot, it doesn’t look much like one. CARL is constructed of an aluminum shell with the basic features of other research robots, like a motor and sensors.

“It’s actually a fairly simple design, as far as robots go, but the complexity is more in the brain and the interface,” Cox said of CARL.

Despite its unassuming exterior, the robot has already gained recognition for its innovative brain. A paper by Krichmar and Cox on their research was featured in IEEE Robotics and Automation Magazine.

CARL wasn’t only designed as a moving, interacting artificial brain but as tool to understanding the human brain, whose systems have yet to be explored and understood fully.

“The reason we’re using a rodent [as a model for the human brain] is because they have brains very similar to human brains [in terms of layout] … we can use rat brain data as a nice model for human behavior,” Krichmar said.

The human mind at this time cannot be recorded in the resolution needed to explore the activity of neurons in depth. Krichmar and Cox are studying how an animal focuses its attention and responses to unexpected alterations in its environment, all aspects of behavior located in four brain systems.

Eventually CARL’s brain, which now includes brain systems that respond to rewarding and punishing signals from the environment, will encompass other areas of the mind dealing with focus and uncertainty. The group at UCSD is currently collecting data on the cholinergic and noradrenergic systems.

“The neurons in these parts of the brain [the noradrenergic and the cholinergic] haven’t been recorded very often. It’s brand new data. And they’re systems that are involved in various different neurological disorders as well,” Nitz said of those areas that may be damaged in people with Alzheimer’s disease and Attention Deficit Disorder. Nitz hopes his research will lead to a better understanding of disorders like these.

CARL will soon move onto identifying shapes like lines, squares and triangles, and, as Krichmar and Cox plan to take their experiments outside the laboratory, perhaps even onto the UCI campus.

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