# THE ARM THAT WILL BLOW YOUR MIND

Patrick Pilarski has deep reserves of enthusiasm—and it's contagious. Speaking to a group of high school students in a Faculty of Engineering DiscoverE outreach camp last summer, he explains how reinforcement learning can make machines 'intelligent.'

Using a small robot called the CritterBot and a simple Wii video game control pad, Pilarski demonstrates that by using positive or negative feedback—pressing the plus or minus symbols on the pad—the students can 'train' the robot to do their bidding. One student teaches the robot to spin in a counter-clockwise direction. Another teaches it to use its motion detectors and follow a soccer ball.

All the while, Pilarski explains reinforcement learning and artificial intelligence by comparing it to the human experience. He reminds students what it was like the first time they dribbled a basketball—how awkward and clumsy they were. But the more they practised, the easier the action became. One student compares that type of muscle-memory to learning to play the clarinet.

With the parallels he draws between computers and humans, it's no surprise that Pilarski sees prosthetic limbs of the future acting co-operatively with people.

"If you're a carpenter and you lose your arm in an accident, why not have a hammer for a hand?" he asks. "Or if you're doing drywalling, why not have a drill?"

But Pilarski envisions a future in which it isn't just form and function that make prosthetics special—but the 'intelligence' they have and the 'decisions' they make. It's a brave new world with no limits. Imagine, for example, an arm that telescopes out, extending your reach to the top shelf in your kitchen because it 'knows' you're cooking.

Pilarski explains it this way: we've got the computing horsepower to put all kinds of sensors into a prosthetic arm—a computer that knows what time it is and what the date is, a device that measures air temperature, accelerometers and force sensors so an arm knows something about its own motion. And importantly, it has memories it can draw upon. Using all the data its sensors provide, a prosthesis could arrive at the conclusion that on Wednesday night at 8 p.m. it is at the bowling alley. Having determined its whereabouts, it prepares to move its wrist and elbow accordingly. Or, it could realize that every weekday at 6 p.m. it is in the kitchen preparing dinner and that a shrug of the shoulder from its owner, in this setting, means the arm should telescope out to reach that bag of rice on the top shelf of the pantry.

The arm would act in the context of its environment. Pilarski wants to see limbs that adapt to their owners' lifestyles, constantly comparing their current state to previous performances and standard-setting calibration tests. "When I'm in the car, it would know if I am reaching for the stereo or the rear-view mirror, because it knows where the stereo is. So my hand would open to just the right size when I reach for the rear-view mirror, because it figures out that I am going to adjust the rear-view mirror. And when I bring my hand to my face, it figures out that I want to adjust my glasses.

"Our computational power is going through the roof, and the amount of data we have coming in is getting bigger and bigger—it's like a fire hose. It is on our shoulders to develop methods to capture this data and do something with it," he says.

**"I'm in the business of applied science; at heart, I am an engineer. I like applying theory to real-world domains."**

— PATRICK PILARSKI

Now doing post-doctoral research with the university's Reinforcement Learning Artificial Intelligence Laboratory and the Alberta Ingenuity Centre for Machine Learning, Pilarski says his head spins when he considers the phenomenal advances that have been made there. "These labs are developing cutting-edge artificial intelligence and machine-learning methods.

"I want to figure out how these techniques can be applied to real-world problems. I'm in the business of applied science; at heart, I am an engineer. I like applying theory to real-world domains. Through my work, I want to pursue discipline-crossing research and do some good with it."

— **Richard Cairney**

**Patrick Pilarski explains how artificial intelligence and machine learning parallel human intelligence and learning.**

Jimmy Jeong