Monkey Think, Robot Do

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Scientific American
15.01.2008

A rhesus monkey uses thought to make a robot walk, paving the way for paralysis victims to move using brain-powered prosthetic limbs

In a major step toward helping victims of paralysis walk again, researchers at Duke University Medical Center today announced that they had proved monkeys can use their brainpower to control the walking patterns of robots.

The Duke researchers, working with the Computational Brain Project of the Japan Science and Technology Agency, implanted Idoya, a rhesus monkey, with electrodes that gathered signals from her brain's motor and sensory cortex cells as she ambled along on a specially built child-size treadmill. The electrodes recorded the cells' responses as the monkey walked on the treadmill at different speeds; simultaneously, sensors on Idoya's legs tracked their patterns of movement. The information was transmitted in real time from their lab in Durham, N.C., to control the commands of a five-foot-tall humanoid robot (see video here) in Kyoto, Japan.

"We can read signals from cortical areas…the motor and sensory areas of the brain that are involved in the generation of the motor program to walk," says Duke neuroscientist Miguel A. L. Nicolelis. "And we are able to read these signals, decode them, and send them to a device…a bipedal robot that actually starts walking like a monkey."

Through the electrodes implanted in Idoya's brain, researchers found that certain neurons in several regions fire at different phases and frequencies, depending on their role in the complex, multimuscle motor process. During the experiment, the robot continued to move for several minutes after Idoya stopped strolling on her treadmill, indicating that her neural impulses were controlling the metal man's limbs. "She was certainly thinking about the same thing as when she was walking," Nicolelis says. "If she was thinking about grasping bananas, we wouldn't get the same patterns."

The goal of Nicolelis and his colleagues is to pave the way for real-time direct interfaces between a brain and electronic and mechanical devices that could be used to restore sensory and motor functions lost through injury or disease. "Our hope is that one day soon," Nicolelis and his former postdoctoral fellow Sidarta Ribeiro wrote in a December 2006 Scientific American article entitled "Seeking the Neural Code," "we will also master sufficient syntax to talk back to the brain, which would allow us, for example, to build a human prosthetic arm laden with sensors to send tactile feedback into the somatosensory cortex of its user."

The experiment in monkey-to-robotic motion culminates years of studying the primate brain's ability to stimulate robotic arms via neural signals. In 2000 Nicolelis and his colleagues described how they had reliably translated the raw electrical brain activity of an owl monkey named Belle into signals that successfully directed the actions of robotic arms based both at Duke and at a Massachusetts Institute of Technology lab 600 miles (965 kilometers) away in Cambridge, Mass. Belle's tiny hand moved a joystick left or right to correspond with a horizontal series of lights on a display panel in a Duke lab; both robot arms followed suit.

A few years later, in 2005, Nicolelis and his team listened in on brain signals generated by a rhesus monkey named Aurora using a joystick to play a video game and translated them into commands for a mechanical arm to duplicate the motions. Aurora was ultimately able to move a robotic arm sans the joystick, using only her thoughts, an experiment that Nicolelis says addressed "fundamental questions about how brain circuits operate."