Replicating an Eel's Nerve Circuitry May Aid Paralyzed People

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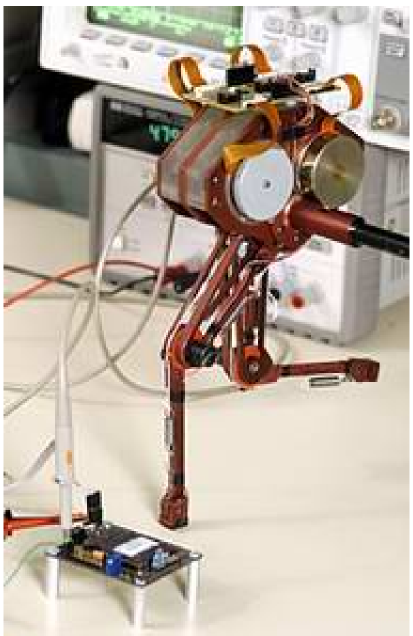

In a collaboration that blends biology and robotics, researchers at Johns Hopkins and the University of Maryland are unraveling the circuitry in an eel's spinal cord to help develop a microchip implant that may someday help paralyzed people walk again.

After a spinal cord injury, many patients are unable to move because the brain is cut off from nerve control centers called central pattern generators, which are believed to be located in the lower back. The two-school research team's goal is to make a device that could mimic the signals sent by the brain and coax these nerve centers into sending "walking" instructions to muscles in a patient's legs.

This is a challenging, long-term project, but we believe it has a good chance to succeed," said Ralph Etienne-Cummings, an electronics and robotics expert who is lead researcher on the project at Johns Hopkins. "Our first step is to learn how the brain transmits electrical messages along the spinal cord that tell the legs what to do. Then, we want to make microchips that replicate this process. We've started by modeling the way swimming signals move along the spinal cord of a lamprey eel."

Etienne-Cummings, an associate professor in the Department of Electrical and Computer Engineering at Johns Hopkins, specializes in designing robotic devices that operate in ways that resemble those found in biological organisms. In the spinal cord project, he is working with Avis H. Cohen, who has spent many years studying the lamprey's nervous system and how it directs swimming. Cohen is a professor in the Department of Biology, Neuroscience and Cognitive Science at the University of Maryland, College Park.

"Even though the lamprey is a very primitive vertebrate, we and others have shown that it's remarkably like humans in the ways it makes and controls its locomotion," Cohen said. "But unlike that of humans, the lamprey's nervous system is remarkably easy to study."

The recent death of actor and research advocate Christopher Reeve has increased the public's awareness of efforts to help people with spinal cord injuries. The team led by Etienne-Cummings and Cohen has already published a paper describing the use of a microchip version of a biological central pattern generator to produce a lifelike gait in a robotic leg. In this project, funded by the U.S. Office of Naval Research, the university researchers collaborated with M. Anthony Lewis of Iguana Robotics, Inc.

The researchers are now moving to expand their project by developing a neuroprosthetic implant that would connect to human central pattern generators to restore locomotion in patients with spinal cord injuries.

The lamprey is an ideal starting point, Etienne- Cummings said, because the eel's spinal cord can be removed and kept alive in a lab solution. By adding chemicals, the eel's excised spinal column can be stimulated to produce the pattern of nerve signals seen when a live eel is swimming. "My collaboration with Prof. Cohen began when we tried to model the lamprey's spinal cord circuits on a silicon microchip," Etienne-Cummings said. "That provided us with a more natural way to control robotic limbs. But it also showed us a possible way to interface electronically with human biology."

To restore movement in patients with spinal cord injuries, other researchers are trying to regrow severed nerves or directly stimulate the muscles in paralyzed limbs. Etienne-Cummings and Cohen are pursuing a different but possibly complementary approach. They believe that even when the central pattern generators that guide movement from the lower back are cut off from the brain, they remain viable.

A properly designed implant, they believe, could act in place of the brain and direct these dormant control centers to send the same kind of locomotion signals they did before the spinal cord was injured. "We want to take advantage of circuits that already exist in the body,"

Etienne-Cummings said. "Instead of stimulating the leg muscles directly, we want to go to the spinal cord and stimulate the nerves that control the muscles in the legs."

He envisions the device that would accomplish this as one that would contain mixed-signal (analog and digital) very large-scale integrated microchips. The device would be small and relatively inexpensive, running on a low- power, rechargeable battery.

Etienne-Cummings cautioned, however, that much work lies ahead. After the researchers conclude their studies on lampreys, they must determine whether the results can be transferred to small mammals, such as rats. Routine use in humans could be at least 10 years away.

The continuing research has been supported by funding from the Office of Naval Research, the National Science Foundation and the National Institutes of Health.

Source: Johns Hopkins University

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