Mind Control

University researchers develop brain chips to move artificial limbs, detect seizures

The 1970s TV series "The Six Million Dollar Man" featured an astronaut so badly injured in an accident that surgeons could save his life only by "rebuilding" him. The character was repaired with machine-like components during an expensive experimental surgery that left him with superhuman powers.

Sound like science fiction? Maybe 40 years ago.

"There has always been a drive to come up with a computer that will emulate the smartest entity in the universe. What's the smartest entity in the universe? The brain. We are at a point where that is possible," said Dr. Magdy Bayoumi, head of the Department of Electrical and Computer Engineering.

DOUG DUGAS

From left: Zag ElSayed, an adjunct professor; Nelly ElSayed, a doctoral student; and Dr. Magdy Bayoumi, head of the Department of Electrical and Computer Engineering

Bayoumi is leading a group of researchers at the University of Louisiana at Lafayette who are developing a brain chip in the University's Intelligent Cyberphysical Lab. It would enable a person to move an artificial limb via thought. A small chip in the brain – about one inch square – would let someone with a prosthetic limb move it as if it were flesh and bone.

How? Through brain-computer interface, or BCI, technology. As the name implies, brain-computer interface establishes a link between a brain "wired" with a computer chip, for instance, and a device that enables brain signals to direct external activity, such as moving an artificial limb.

"It's basically integrating a brain with a system, to be able to read the brain or read what's *inside* the brain," Bayoumi explained.

Sensors inside the microchip, which would be surgically implanted in the brain, would detect biological processes that convert thought into action. Brain signals would be transmitted to a second chip in a prosthetic arm by way of a radio frequency signal. The virtual channel would enable brain impulses to prompt physical movement.

"It sounds like fantasy, but so did the smartphone. Not very many people envisioned a wireless device that would let you talk to anyone, anywhere in the world," Bayoumi said.

University scientists are developing a second microchip that would give people suffering from epilepsy a warning that a seizure is imminent.

The chip would be placed inside a smartphone or wristwatch-like device and synchronized with sensors embedded in headgear similar to a swimmer's cap. The chip would wirelessly predict epileptic seizures by monitoring brain signals with EEG, which stands for electroencephalography. An alert would be delivered in advance of a seizure.

Technology that can be used to predict epileptic seizures already exists. It only provides warning about eight seconds beforehand, though. Bayoumi said University researchers are hoping to produce a chip that would give a person ample notice before a seizure strikes.

"Specially-trained dogs can predict a seizure about 14 minutes before it happens, and that is our goal. We want to produce a chip that can compete with a dog, which would be a much more practical way to deliver a warning," he explained.

A person suffering from epilepsy would have time to call for medical help or to stop his vehicle to reduce chances of a seizure-induced accident, said Nelly ElSayed, a graduate student working on the project. Alert devices could also be worn by a relative, friend or caretaker who could assist a person suffering from epilepsy, call for help or remotely disable a vehicle.

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University researchers are developing sensors for the brain, similar to the one shown.

ElSayed, who is pursuing a doctoral degree in computer engineering, said the technology would be advantageous for people who are unable to communicate in the event of a seizure, such as "infants or people in a coma who can't explain what's happening.

"The system could be programmed to call a hospital, and have GPS so an ambulance could come to the location of a person in danger. It could save lives."

Bayoumi describes its significance this way: "There will be transformational impact – not an incremental one – on improving quality of life."

Both projects are supported with grants awarded by the National Science Foundation and U.S. Department of Energy.

The idea of "reading minds" and thought-controlled movement has been fantasized about for decades. The origins of what today is called brain-computer interface began in the 1920s, when German psychiatrist Hans Berger measured and recorded human brain activity using EEG.

An EEG test can assist in the diagnosis of a range of conditions related to the brain, including epileptic seizures, concussions, and tumors. The test, however, involves placement of electrodes on the scalp, with results transferred by way of a conductor to costly and complex equipment. Such EEG tests can only be conducted in hospitals or labs by medical professionals.

In the case of thought-controlled movement, a big leap forward occurred in the 1970s when researchers at the University of California, Los Angeles were able to control a computer cursor by using EEG signals from the brain.

More recently, scientists and neurosurgeons have demonstrated that prosthetic limbs can be manipulated in a lab setting. Nerves in a torso, for example, are surgically reprogrammed to direct neural commands to a prosthetic limb.

Many challenges remain. Much of today's existing technology – including technology that has been approved by the U.S. Food and Drug Administration – is either dangerous or inconvenient for use by the average person. Cost is another drawback. A prosthetic limb capable of spurring limited thought-controlled movements, such as one developed in lab tests at Johns Hopkins University, would cost about $500,000.

Brain surgery to implant chips and electrodes is risky. Research on wireless BCI systems is embryonic, and subject to hurdles such as noise interference and accuracy, and data speed and storage limitations.

"In the case of a chip to detect epilepsy, we have one that works, but we are constantly improving it. Right now, we are trying to improve accuracy. Our system is good, but sometimes it predicts a seizure will happen, and doesn't. It has to be 100 percent for people to use it," ElSayed said.

UL Lafayette researchers have been working to complete prototypes and fabricate models of each of the two chips. Once that happens, Bayoumi said the plan is to partner with a medical school or a private entity to conduct trials and explore the potential for commercialization.

As the technology continues to evolve, the possibilities for medical breakthroughs are far-reaching. Chips could be used to help people paralyzed by spinal cord injuries regain movement, or to monitor brain activity to aid diagnosis and treatment of dementia and mental illness.

"Diagnosis and treatment of mental health problems are very lagging compared with other areas of medicine. There are really no conclusive tests. For the body, you can do a blood test, or an MRI. So, to be able pick up a signal from the brain and analyze it for depression, for example, would present a fantastic breakthrough," Bayoumi said.

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