Haptic technology aims to overcome physical and psychological effects of upper limb loss

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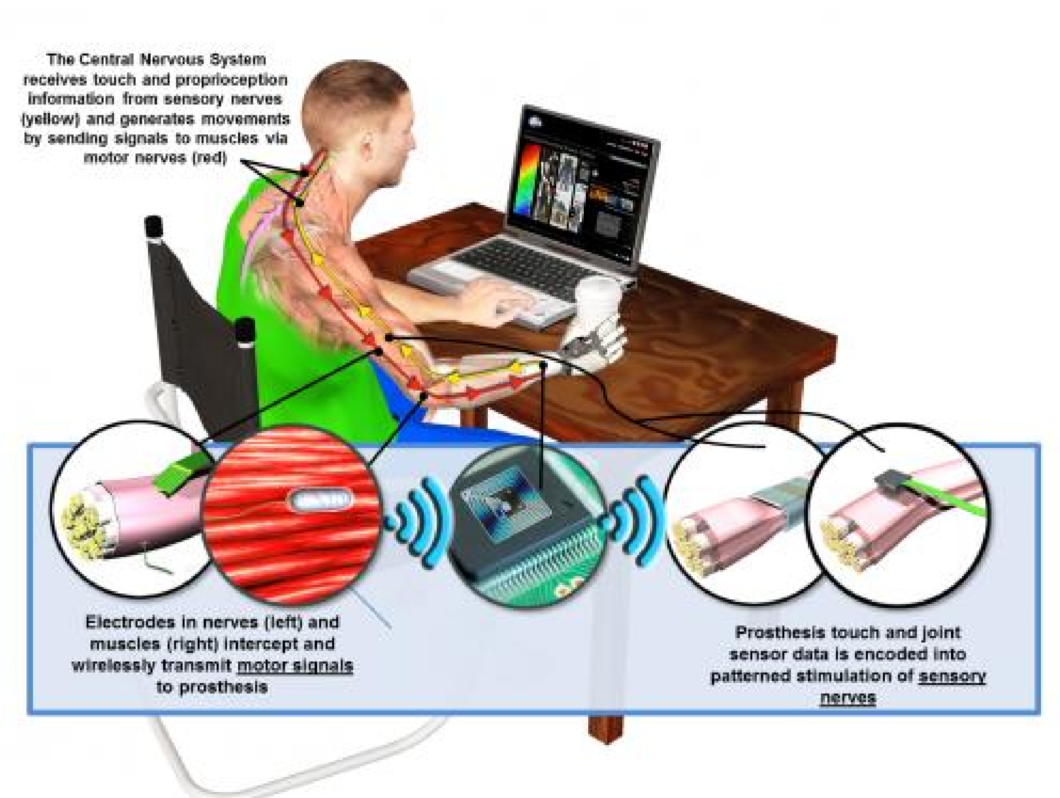

To understand the meaning of "proprioception," try a simple experiment. Close your eyes and lift your right arm above your head. Then, move it down so that it's parallel to the ground. Make a fist and release it. Move it forward, and then swing it around behind you like you're stretching.

Finally, freeze in place, open your eyes, and look. Is your arm positioned where you thought it would be?

For most people, the answer will be, "Yes." That's because your brain and nervous system worked together to move your body according to your intent and processed the sensory feedback to know where your arm was in space despite not being able to visually track it.

For many upper-limb amputees using prosthetic devices, the answer would be, "No." They wouldn't have confidence that their device would be where they think it is because current prostheses lack provisions for providing complex tactile and proprioceptive feedback to the user. Without this feedback, even the most advanced prosthetic limbs will remain numb to the user and manipulation functions will be impaired.

DARPA's new Hand Proprioception and Touch Interfaces (HAPTIX) program seeks to deliver those kinds of naturalistic sensations to amputees, and in the process, enable intuitive, dexterous control of advanced prosthetic devices that substitute for amputated limbs, provide the psychological benefit of improving prosthesis "embodiment," and reduce phantom limb pain. The program builds on neural-interface technologies advanced during DARPA's Revolutionizing Prosthetics and Reliable Neural-Interface Technology (RE-NET) programs that made major steps forward in providing a direct and powerful link between user intent and prosthesis control.

HAPTIX aims to achieve its goals by developing interface systems that measure and decode motor signals recorded in peripheral nerves and/or muscles. The program will adapt one of the advanced prosthetic limb systems developed under Revolutionizing Prosthetics to incorporate sensors that provide tactile and proprioceptive feedback to the user, delivered through patterned stimulation of sensory pathways in the peripheral nerve. One of the key challenges will be to identify stimulation patterning strategies that elicit naturalistic sensations of touch and movement. The ultimate goal is to create a fully-implantable device that is safe, reliable, effective, and approved for human use.

"Peripheral nerves are information-rich and readily accessible targets for interfacing with the human nervous system. Research performed under DARPA's RE-NET program and elsewhere showed that these nerves maintain motor and sensory fibers that previously innervated the amputated limb, and that these fibers remain functional for decades after limb loss," said Doug Weber, the DARPA program manager. "HAPTIX will try to tap in to these biological communication pathways so that users can control and sense the prosthesis via the same neural signaling pathways used for intact hands and arms."

In addition to the improved motor performance that restored touch and proprioception would convey to the user, mounting evidence suggests that sensory stimulation in amputees may provide important psychological benefits such as improving prosthesis "embodiment" and reducing the phantom limb pain that is suffered by approximately 80 percent of amputees. For this reason, DARPA seeks the inclusion of psychologists in the multi-disciplinary teams of scientists, engineers, and clinicians proposing to develop the electrodes, algorithms, and electronics technology components for the HAPTIX system. Teams will need to consider how the use of HAPTIX system may impact the user in several important domains including motor and sensory function, psychology, pain, and quality of life.

"We have the opportunity to not only significantly improve an amputee's ability to control a prosthetic limb, but to make a profound, positive psychological impact," Weber said. "Amputees view existing prostheses as if they were tools, like a wrench, used only to perform a specific job, so many people abandon their prostheses unless absolutely needed. We believe that HAPTIX will create a sensory experience so rich and vibrant that the user will want to wear his or her prosthesis full-time and accept it as a natural extension of the body. If we can achieve that, DARPA is even closer to fulfilling its commitment to help restore full and natural functionality to wounded service members."

The program plan culminates with a 12-month, take-home trial of the complete HAPTIX prosthesis system. To aid performers in the completion of the steps necessary to achieve regulatory approvals for human trials, DARPA consulted with the U.S Food and Drug Administration to incorporate regulatory timelines into the program process.

"Once development of the HAPTIX system is complete, we want people to benefit immediately and be able to use their limb all day, every day, and in every aspect of their lives," Weber said. "The experience needs to be comfortable and easy. Take-home trials are the first step in making that vision a reality."

If it is successful, the HAPTIX program will create fully-implantable, modular, and reconfigurable neural-interface microsystems that communicate wirelessly with external modules, such as the prosthesis interface link. Because such technology would have broad application and could fuel future medical devices, HAPTIX also plans to fund teams to pursue the science and technology that would support next-generation HAPTIX capabilities.

More information: Full details of the HAPTIX opportunity are available on the Federal Business Opportunities website at: go.usa.gov/kyjJ

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