A HELPING HAND

The rapidly advancing field of robotics is offering new hope for those with physical limitations

SEIJI UCHIDA NEVER THOUGHT HE WOULD BE ABLE TO visit France after he was paralysed in a car accident 28 years ago. But in February 2011, the Japanese citizen found himself exploring a medieval abbey on the rocky island of Mont St Michel. Besides fulfilling a dream to see the picturesque site, Uchida wanted to show that disabled people could visit the world's heritage sites without extra assistance if the right technology is available.

His independence came thanks to the Hybrid Assistive Limb (HAL), a robotic suit that assists paralysed patients with mobility by anticipating their movements, allowing those who would otherwise be confined to a wheelchair to walk.

The world of robotics is rapidly advancing. Technologies being developed sound like science fiction: robots can assist us in our homes, help organise warehouses and build cars. But perhaps their most fascinating and inspiring use is as assistants for the disabled. For people without basic mobility, robotics offers potential that they might have never even dreamed of.

For those who can afford it, robots are already helping mobility-restricted individuals accomplish basic tasks. While service robots can follow commands from the elderly or disabled to perform actions they are no longer able to, avatar robots can stand in for humans – Stepan Supin, a boy in Moscow with leukaemia, uses a robot to go to school while he is confined to bed.

But next-generation technology allows robotics to work as one with human bodies that cannot function anymore. Bionic technologies have become so advanced that even those who are completely paralysed might soon find ways to move.

Researchers at the CNRS-AIST Joint Robotics Laboratory are developing software that allows a person to control a robot with their thoughts alone. An electroencephalography (EEG) cap outfitted with electrodes reads the electrical activity in the patient's brain, which is interpreted by a signal processor. As the user concentrates on instructional symbols on a screen, the robot interprets them as commands. Technology also exists that allows a patient to issue commands using only eye movement: a laboratory at the Université Pierre et Marie Curie-Paris recently used eye movement to write on a computer screen.

For those missing a limb – particularly in the lower half of the body – prosthetics have long been important in regaining mobility. But when a hand or arm has been lost, prosthetics have often been limited to masking the missing limb. In recent years, this has changed with the advent of robotic prosthetics like the i-limb, a bionic prosthesis developed by British company Touch Bionics. "The i-limb Ultra Revolution is our latest full prosthetic hand, and provides a greater range of functionality than has ever been possible before in upper-limb prosthetics," explains Ian Stevens, CEO of Touch Bionics. "This product comes with a powered rotating thumb and can be configured to the specific needs of the wearer using our iPhone app. Amputees tend to have a range of different expectations of their prosthesis but, in general, they want a product that increases their functional capabilities and is also visually appealing."

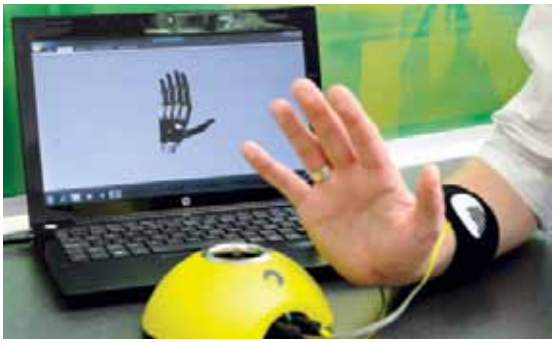
The i-limb is made of lightweight aluminium and high-density plastics, and is relatively easy to use. "While it varies from person to person, a typical user is able to become quite proficient with around five days of training," Stevens says. "Of course, people continually learn how to get more out of their prosthesis the longer they wear it."

The limb works by reading the electrical signals from the wearer's muscles, resulting in a futuristic bionic fusion between the wearer and the device. "The wearer of an i-limb prosthesis controls the movements of the hand through the small electrical signals emitted by the muscles in the remaining portion of their limb," Stevens explains. "This is known as myoelectric control, and it has been in use in prosthetics for many years. Touch Bionics has innovated this by adding wireless computing to the hand, allowing the wearer to configure their muscle signals to specific actions. For example, pointing a single finger, pinching between thumb and forefinger or any number of custom grips and gestures."

FOR THOSE WHO HAVE LOST THEIR BASIC MOBILITY, ROBOTICS OFFERS POTENTIAL THAT THEY MIGHT HAVE NEVER EVEN DREAMED OF

Suits like HAL provide one of the most intriguing solutions for those with damaged nervous systems or legs. One of the exciting companies working with this technology today is Ekso Bionics. Founded seven years ago by engineers in Berkeley, California, Ekso takes its name from the word "exoskeleton", a skeleton on the outside of the body.

FROM LEFT: The Ekso suit, from Ekso Bionics, straps over the patient's clothing, using signals from parts of their bodies that they can move to receive commands; robotic prosthetics like the i-limb provide greater functionality than has ever been possible before in upper-limb prosthetics.



CLOCKWISE FROM TOP LEFT: Advancements in mobile technology offer new solutions for prosthetic software; the i-limb is made of lightweight aluminium and high-density plastics; the virtu-limb by Touch Bionics.

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The Ekso suit straps over the patient's clothing, using signals from parts of their bodies that they can move to receive commands. "Ekso enables individuals with lower extremity paralysis to stand up and walk over ground with a weight-bearing, reciprocal gait," explains Allison Sojka, director of marketing at Ekso. "Walking is achieved by the user's forward lateral weight shifting to initiate each step. Battery-powered motors drive the legs and replace deficient or lost neuromuscular function."

"New Variable Assist software facilitates early over-ground ambulation for people with lower extremity paralysis or hemiparesis due to neurological disorders," Sojka continues. "It helps patients balance the physical effort they exert with the amount of help they need to achieve a more normalised gait. It also allows clinicians to augment their patients' strength and provides the ability to strategically target deficient aspects."

Newer advancements, however, are allowing the company to fine-tune the suit's interaction with the patient. "Initially, Ekso was designed to provide 100 percent of the power required for people with spinal cord injuries to stand and walk," explains Sojka, "Our Variable Assist software means Ekso can now tune the amount of power it contributes to either of an individual's legs to help them walk. This provides new opportunities for therapeutic interventions for people not just with incomplete SCI, but also stroke survivors or others with hemiparesis, to potentially learn to walk again."

Candy Tefertiller, the director of physical therapy at Craig Hospital in Denver, Colorado, has integrated the Ekso suit into their therapies. "What we're trying to show is that we can implement its use safely on a daily basis and give everyone the ability to get upright and moving," she says. "That's healthy for the cardiovascular system, the digestive system and the musculoskeletal system."

The hospital's Peak Centre allows patients to train daily with the Ekso suit and a physical therapist. "Those individuals who have incomplete neurologic injuries can be up safely on their feet and re-teach the nervous system normal walking patterns with the suit," Tefertiller elaborates. "For patients who have motor-complete injuries and have been in a chair a long time, it means that first opportunity to get upright, being able to be eye to eye with individuals as they are talking. The hope for the future is that they will be able to continue their lives in an upright position, or at least choose whichever is most efficient for them."

Paolo Milia, MD, PhD and chairman of the Rehabilitation Unit at Prosperius Institute in Umbria, Italy, also uses the Ekso as a key rehabilitation tool. "[Patients] can begin rehabilitation training soon after admission with spinal cord injury," he explains. "This is important because we need to achieve the best results before the brain and the spinal cord starts to work alone. There are many aspects like stiffness, reduced range of movement and atrophy of muscles that can be prevented by treatment with the Ekso. We have achieved excellent results."

At the moment, the Ekso is intended to be used under medical supervision, but already a few individuals use the product privately. "There are already a handful of individuals who own their own suits," says Sojka. These include Mark Pollock, a blind Irish adventurer who suffered a severe spinal cord injury, and will soon include Andrew Merryweather, a South African paralysed after an assault seven years ago, who is raising money to purchase a suit for his community.

There's a wide range of reasons that people find themselves in need of an assistive limb, from diseases to accidents. This has left prosthesis-wearers with varying levels of functionality, but the ultimate goal for any wearer is the same: to achieve autonomy. "Touch Bionics prosthetics are designed to provide the wearer with improvements in functionality that lead to greater levels of independence," Stevens says. "This means that wearers of our products can reduce their reliance on others to help them in their daily activities, which is extremely important to most people with limb loss."

Advancements in these technologies are accelerating as quickly as any other technology field today. Bionic companies therefore often work together closely on research and development to stay ahead of prosthetic developments. "As recently as ten years ago, exoskeleton technology was just science fiction: today it's fact," says Sokja. "The development of these technologies is only going to accelerate from here."

As an example, developments in mobile technology offer new solutions for prosthetic software, especially relating to wireless technology, allowing greater levels of customisation. "Today it's possible to have a prosthesis that can adapt to the changing needs of the wearer at the touch of a button," says Stevens. "New types of control methods provide wearers with even more functionality – dexterity and ease of use will make a big difference in our industry in the years to come. As the interface between our human systems and external technologies becomes more natural and intuitive, the benefits to prosthesis wearers will become more profound."

WORDS JESSICA GLIDDON