Robotic hand responds to intention signals

Remarkable breakthroughs help stroke victims regain use of their hands

WHEN THERE IS a major interruption to the supply of blood to the brain, serious consequences usually follow. This cerebral event, known as a stroke, is the leading cause of long-term disability and the second biggest cause of death worldwide. Survivors are often left with complex rehabilitation needs, frequently with an inability to move their limbs on one side of their body. In this section, we will look at a range of dramatic advances taken to improve their lives.

The helping hand
The patient has had a stroke. On one side of her body, she can barely move her hand. She wants to pick up something, or press a button, or operate a handle, but her fingers refuse to obey. She feels deeply distressed, feeling as if her body is giving up on her. This is the tragedy of physical impairment. The physical loss of capabilities is hard to deal with, but then depression adds to the patient’s woes.

“Combining advances in robotics and neuroscience, the robotic hand enables stroke survivors to restore movement to a paralyzed hand.”

Mr Michael Tsui, CEO of Deltason Medical Limited.
That’s when a device called “the Hand of Hope” steps in. It looks like something from The Terminator movies, a robotic hand with lots of individual joints for its metal fingers. The sufferer attaches it to the back of her hand as an exoskeleton to overlap on her fingers.

Now this is where the magic happens. It may look like it is going to take control of the situation and work on her behalf, but it doesn’t. Instead, it does something much more spectacular. It leaves full control to the user. She thinks about what she wants to do. She urges her fingers and thumb to move in certain ways, but this time, they do as they are told! They obey instantly.

The way the machine knows what she wants to do and the way it brings action back to her fingers seem like a miracle — especially since there are no wires connecting the device to her brain. No part of the device penetrates the skin at any point. This is one of those moments where you really feel that technology creates magic.

And it is a joy to watch patients try out the new device. After 20 sessions, without surgery or any penetration of the skin or muscles, they can once again pick up a drink with their “bad” hands. The pleasure on their faces is clear.

So how does it work? The great thing is that the process is quite simple. Electrodes from the device sit on the surface of the patient’s forearm. They detect the signals that the brain is sending to his or her hand muscles: signals that are sometimes so faint that no movement is visible to the human eye. You may not see a muscle twitch, but the machine detects these tiny signals. It then amplifies the signals up to 1,000 times, and passes the information to the robotic hand. The result is that the brain’s request is carried out. The processing happens instantly, so that the wearer perceives the result as if his or her hand had become usable again. The robot hand doesn’t drive the fingers, but assists them.

How did this breakthrough take place? Dr Raymond Kai-yu Tong of PolyU’s Interdisciplinary Division of Biomedical Engineering noticed that most of the aids designed to help stroke sufferers, directed their movements, so that the contribution of the patient was passive. He felt that the initiative should come from the patient, not the machine, and thus he designed the robotic hand. “We rely on the user’s will-power,” he said.
Respecting the intention of the patient may seem to be a small difference, but it is an important one, which is clear from the thrilled response of the users of the new device.

Although the robotic hand may look like a powerful device from a science fiction movie, it is actually made of aluminium and therefore very lightweight. It has sensors attached to the arms, and a lightweight power unit operated by a battery.

The design of the Hand of Hope has been patented. It is a combined effort from biomedical engineers from PolyU, therapists and patients from various hospitals in Hong Kong, and a research team at Rehab-Robotics. The team is particularly proud of its work, as it is the only robotic system on the market to provide training to individual digits of the hand.

Getting people back to using their affected hand

Stroke patients naturally want to recover as many normal functions as they can. To help them, PolyU scientists have developed a device called a ‘functional electrical stimulation system’ for patients to use at home. It applies electrical stimulation to paralyzed muscles, causing functional movements.

The device is controlled by microprocessors so a therapist can program a tailor-made training regimen for each individual user by detecting their fingers and wrists’ residual motion. And since it is based on digital technology, the patient’s records can be easily stored and analyzed. Doctors can look at the data to ensure that a steady improvement is taking place. The system has one to four channels of stimulation options which can simultaneously activate four different muscle groups, so they can be trained. Motion detector sensors are included in the system, so that data about the movement of the patients is automatically fed back into the machine.

The device, marketed as the HandEase System, has demonstrated excellent results. By stimulating the thumb and index finger, the system helps the user achieve hand open motions and reduces a condition called spasticity, a motion problem caused by muscles becoming resistant to stretching. It has won several awards for its inventors from PolyU, Dr Raymond Kai-yu Tong, Prof. Arthur Mak and Mr Kelvin Leung.

Patients can walk smoothly

A related breakthrough helps victims with lower limb problems. Stroke patients often find that one foot drags on the ground. To try to fix this, patients may lift their hip higher or swing their leg outwards. You may have seen stroke victims walking in this asymmetrical way. Clearly, they would much rather walk normally, but the patients find it is extremely hard to teach themselves to do so.

The experts at PolyU have created a device that helps patients lift the dragging foot precisely the right amount. The device matches a patient’s walking pattern. It can be adjusted to fit the particular individual. Once he or she has practised using it, the result is that the patient will once more have a safer and faster walking gait. This means a lot to stroke victims who feel self-conscious about their foot-drop gait.

This device is known as an Electronic Ankle Foot Orthosis (an orthosis is a limb movement correcting device). It has created great excitement in the rehabilitation circles.

This advanced technology has been licensed to a firm which has the expertise and resources to enhance the device in aspects such as product design, the required clinical studies and technological validation. It also has a large marketing network. Also involved in this project is the Jockey Club Rehabilitation Engineering Clinic, which provided the first Functional Electrical Stimulation service in Hong Kong, featuring both HandEase and the walking device. The service was provided to more than 500 people who had had a stroke or spinal cord injury, or who were children with cerebral palsy.

The systems have also been used in rehabilitation services in hospitals in Hong Kong, the Chinese mainland, Singapore and Thailand.

The inventors were particularly thrilled when they had one patient who used their system for more than 10 years and has just come back for a follow-up visit, and then used it to attend her daughter’s wedding banquet. While scientific breakthroughs can be a joy in their own right, there’s nothing more rewarding than seeing individuals lives enhanced and transformed by new inventions.