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Controlling Cybernetic Machines with the Human Mind

The Fox TV show *Almost Human* gives us a glimpse of what life might be like in the year 2048. The story line has crime out of control and police officer John Kennex (played by Karl Urban) partnered with an almost-human android. I want to draw your attention to a single sci-fi prop in the show. Officer Kennex has a cybernetic prosthetic leg that is fully functional, thought controlled, and in every respect equal to the one he lost in a firefight that he barely survived.

This show made me wonder how close we are to producing mind-controlled cybernetic prosthetic limbs and an android that could pass as human. The new *Robocop* movie made me expand my research to include the development of a brain-controlled exoskeleton suit that would let people paralyzed from the waist down walk again.

Following one of the key guidelines of engineering, form should always follow function. Therefore, work robots don't need to have the same physical parts as people, look human, or have the same physical limits that we have. You might be surprised to learn that human-looking android robots already exist. At this point in time, they just can't run, jump, and think as well as we can. Could you be fooled by the robots in this video: www.youtube.com/watch?v=DF39Ygp53mQ?

A cybernetic limb uses mechanical and electronic systems to duplicate the physical movements of the body part they are designed to replace. For a while now, it has been possible to build such limbs, just not possible to have one automatically controlled by the wearer's mind. A medical team at Sahigrenska University Hospital in Sweden has recently achieved this goal. (See Photo 1.)

During surgery, Dr. Rickard Brånemark permanently implanted neuromuscular electrodes into the arm of an amputee. The team that he led also permanently attached a titanium anchoring system to connect the cybernetic prosthetic limb to the remaining bone in the patient's arm. The surgical procedure, neuromuscular electrodes, and cybernetic prosthetic limb were co-developed by doctors at the hospital and professors and researchers at Sweden's Chalmers University of Technology.

The electrodes that were installed can pick up the electrochemical signals from the nerves in the remaining part of the patient's arm. These signals are created when a person decides to move his wrist, hand, and fingers to do something. If not for the loss of the limb, these signals formed

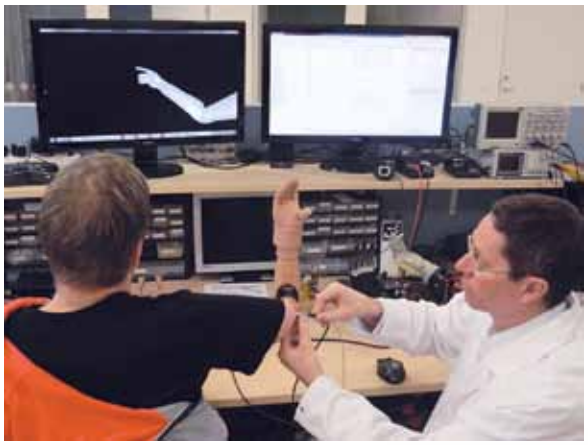

Photo 1—The man with his back to the photographer is the first patient to receive this new mind-controlled cybernetic prosthesis.

Photos 1-3—Centre of Orthopaedic Osseointegration, Sahlgrenska University Hospital

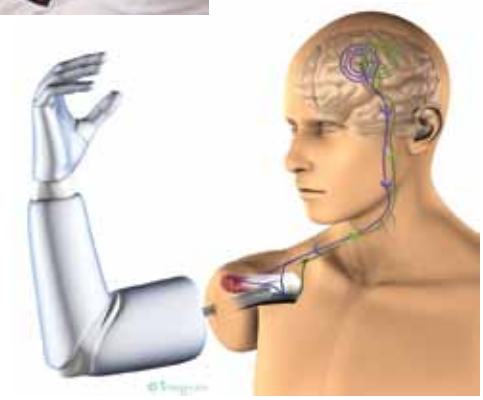

Photo 2—The signals that start in the brain travel along the nerves until they reach the missing limb. The implanted electrodes pick up the signals; a human-to-machine interface converts them into electric currents to precisely run the servo motors in the cybernetic arm and hand.

Photo 3—In the same way that strings on a marionette control a puppet's movement, the electrodes on the scientist's arm let his brain control the movement of the cybernetic hand.

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Photos 4 and 5—3D Systems and Ekso Bionics

Photo 4—Doctors told all of these people that their full lower body paralysis would prevent them from ever walking again. The exoskeletons they are wearing allow them to walk.

in the patient's brain would have caused all the different movements that people make all the time without a moment's thought. (See Photo 2.) The human-to-machine interface interprets these signals and then has the prosthetic perform the movements.

In Photo 3, the model of a prosthesis is moving marionette style, matching a scientist's physical hand movements. Since sensors are only attached to the scientist's skin, the demonstration did not fully reflect how much control the patient actually had after surgery. After the surgery, the patient's cybernetic prosthetic arm received "orders" on how to move from the surgically implanted sensors in the patient's upper arm. The doctors involved have actually created a mind-controlled lower arm similar to the sci-fi arm of Robocop.

What this surgery didn't restore is a sense of what is being touched, its texture, and temperature, so the recipient must carefully watch what he is doing for sensory cues. The degree of motion that has been achieved is shown in this Chalmers University video animation: www.mynewsdesk.com/uk/chalmers/videos/world-premiere-of-nerve-controlled-arm-prosthesis-10751.

At the University of Chicago, researchers are developing ways of enabling an artificial limb to sense contact information such as temperature and pressure. Their goal is to create a feedback loop that could convey this information back to a person's brain.

In a joint project, researchers at Brown University and Case Western Reserve University are working with doctors at Massachusetts General Hospital to develop surgically implantable brain chips to restore the ability to use the paralyzed limbs of patients with spinal cord injuries. The goal is to create new electrical pathways to get the messages from a working brain to the nerves that tell arms, hands, legs, and feet to start moving again.

Photo 4 shows people paralyzed from the waist down who are walking again. The lower body exoskeleton that they are wearing (Photo 5) makes it possible for them to walk with the assistance of two crutches. This system was co-developed by Ekso Bionics and 3D Systems.

Each exoskeleton structural frame is 3D printed to match a 3D body scan of the person it will fit. Each joint in the exoskeleton has sensors and motors that do the actual walking. The exoskeleton system is activated when the wearer pushes a button, and the person controls motion by shifting his or her weight.

This exoskeleton is not yet mind controlled, but a mind-controlled exoskeleton named Mindwalker is now under development in a joint research project at many different European Union institutions in Germany, Belgium, and Italy.

All over the world researchers are hard at work on creating cybernetic answers to restore paralyzed limbs or create new fully functional body parts. Google recently purchased eight different cutting-edge robotics firms. Google's entry into the field of cybernetics could speed up the development of new robotic cybernetic systems. The next Google Android just might walk, talk, and look almost human!

Photo 5—Each exoskeleton is custom made to fit its wearer. The person is 3D scanned; the results become the digital instructions for a 3D printer that generates a perfect-fitting exoskeleton. Motors, sensors, and other actuators are then added so the person can walk again.

Recalling the Facts

1. Do any of your favorite television shows, movies, or video games include mind control or android people in their plots? Which include them and how are they important to the story or game?

2.Which of the following do you think will first move beyond the research phase? Why?

a. Major advances in cybernetic restoration of human capabilities on par with police officer Kennex's leg in the TV show *Almost Human.*

b. A mind-controlled exoskeleton that will get paralyzed people walking again.

c. Humanoid robots similar to the MX robots in the TV show *Almost Human* that are capable of performing most of the mental and physical things that people do today without human intervention.