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## Make way for the Bionic Man

By [Yuval Dror](#)

"In another 50 years, new creatures, a new species of humans will live among us. It is entirely possible that in the future they will make up the majority of humanity. They will be known as robo-sapiens." This declaration did not come from science fiction master Isaac Asimov, but rather from Dr. Amir Karniel, an expert in electrical engineering from the Technion, a researcher in the area of "motor control," which aims to discover how the brain controls the movement of the body, sends instructions and receives feedback from the nervous system.

One of the research methods is to attach biological systems to mechanical ones and in this way create cyborgs, a combination of living and robotic systems. The ultimate goal of the study is to create prosthetic limbs that can replace hands, arms, legs and other body parts. Karniel believes people will eventually prefer the artificial limbs to their own natural ones.

It all began with the vision of scientists in the 1940s and 1950s. They wrote scholarly articles in which they claimed that by the beginning of the 21st century, humans will be spending time in the company of robots, whose main advantage will be that they will be able to clean the house. The illustrations that accompanied the articles appeared to be taken from science fiction: a human-like robot made of tin holding a broom and sweeping the floor. The scientists, however, did not consider two facts, which in retrospect make their predictions look a little ridiculous. The first is that computers specialize in complex calculations and that is why they are excellent chess players, something the scientists hardly considered. The second is that even if it were possible to exploit the ability of robots to dust bookshelves, a way to get them to walk like humans would first have to be found. "The brain's main activity is to control movement. Even speech is a type of movement. The entire human nervous system is built for one purpose - to move: to flee or attack, but to constantly move," explains Karniel. "The fact that we do not know how to build robots that can walk like a five-year-old through dirt shows that we have not yet managed to get down to the root of the way the brain works and the way it operates the muscles by means of the nervous system."

### Reading a monkey's thoughts

This coming Tuesday, a conference organized by Karniel under the auspices of the Israeli Association for Automatic Control will be held at the Daniel Hotel in Herzliya. The conference will be dedicated to the



Dr. Alon Karniel: "I am sure people will be happy to have a bionic hand, leg or eye." (Nir Kafri)

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subject of control and biological systems. Karniel says one of the possible applications of the research of movement is in the world of robotics, which will make it possible to get rid of the wheels that currently serve as legs for most robots. Another possible area for the application of movement research is medicine. "If we can learn how the brain sends instructions we may be able to develop solutions that will help people suffering from problems related to the brain. We may learn how to get muscles that have been paralyzed because the brain is not sending the messages properly to move again."

Karniel has participated in a number of fascinating experiments conducted in the University of Chicago while working on his post-doctorate. In one experiment, the researchers separated the brain stem of an eel-like fish from its body and kept it alive floating in a container filled with oxygenated salt water. They attached a standard Swiss disk-shaped robot with wheels to the floating brain. These electrodes were attached to the left side of the eel's brain as well as to the right side. The container was surrounded with a ring of light bulbs, and each time the researchers flashed a light from a different direction. The robot, which was equipped with light sensors, sent the fish's brain information about the location of the flashing light. In response, the brain sent the robot instructions to move in the direction of the light and it used the wheels attached to it to move.

Karniel tells of other studies whose purpose is to learn about how the brain sends instructions. "In the United States, an experiment was conducted in which a monkey moved a mechanical arm. The electrodes attached to his brain showed the scientists how the brain sends instructions to the monkey's arm to move the mechanical arm," says Karniel. "The study went one step further. The electrodes were attached to the robot and electrical pulses from the monkey's brain were translated into instructions for the robot. This moved the hand parallel to the movement made by the monkey with the mechanical arm. In fact, it is something like 'reading' its thoughts," he says.

#### **'Critters on a chip'**

We can already find commercial applications that combine biological systems with mechanical ones in the field. Michael Simpson of Oak Ridge National Laboratories succeeded in creating bacteria attached to a chip which glows when it comes into contact with chemical substances. The development was sold to a commercial company, which sells the "critters on a chip" to various firms that require a cyborg of this type to help them illuminate the borders of chemical waste dumped in the sea.

In Iowa, entomologist Tom Baker invented a cyborg made up of a tiny processor attached to the antennae of a moth. This cyborg is sensitive to the smell of explosives. When the moth detects this type of smell, the sensor emits a particular sound to help find mines buried in the ground. In Los Angeles, Michael Baudry, an expert in nervous systems, managed to connect

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strips of brain taken from mice and rabbits to a tiny processor and assemble a system that can warn soldiers of the presence of dangerous biological or chemical substances.

The brains of the animals produce a pattern of a normal environment and when the brain senses a change in the pattern, it transmits data by a tiny processor into a warning signal. "The moment we learn what the relationship between the brain and the nervous system and the muscles is, it will be possible to apply the conclusion in two directions," says Karniel. "The first is to build prosthetic devices, say a hand that will be connected to the nervous system. The brain will not be able to differentiate between a natural and artificial hand. This will enable us to replace damaged limbs with artificial ones that are just as good, perhaps even better.

"The second possibility is to connect up to the brain and teach it to use a prosthetic device the way babies learn to use their own hands." Karniel says it is entirely possible that in 20 or 30 years, people will prefer artificial hands to human ones because they perform better. "Who would not want to be Steve Austin?" asked Karniel. "I am sure that people will be happy to have a bionic hand, leg or eye. Why not?"

In fact, maintains Karniel, robo-sapiens, humans that use robotics to improve their lives, already exist. "What is a person that uses a pacemaker if not a robo-sapien," asks Karniel. "And what about people that have artificial implants connected to the auditory nerves that replace their ear? This is a clear example of a combination between a mechanical system and a biological one," he says. One of the problems holding up the scientific breakthrough in this area is related to the way in which experiments in humans need to be conducted.

"We have to find a way to attach electrodes to the brain without it rejecting them and without causing damage to the brain when the head moves. This appears to be a technical problem, but it too has to be solved," explains Karniel.

Like all scientific research, there are serious ethical questions. Karniel admits that this is a complex issue. "In Chicago, where the experiments with the monkeys were carried out, they used to kill the monkeys after the experiment. This is a moral issue - are we prepared to kill a few monkeys in order to see whether it may be possible in a few years to enable people that were unable to walk to use prosthetic limbs created as a result of these experiments." There is also the question of whether people will be willing to place their brains in the hands of scientists, who later may give it instructions. This will concern humanity the moment Karniel and his colleagues present the world with the first bionic hand.



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