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Using the power of thought to control an artificial hand

Dr. Rüdiger Rupp, an engineer from the Department of Orthopaedics at the University of Heidelberg, was awarded the German Society of Orthopaedics and Orthopaedic Surgery's Konrad Biesalski Prize for his outstanding achievements in developing neuroprostheses that can be controlled by weak muscle tension or even by thought power.

Patients with a spinal marrow injury in the neck region are faced with a serious problem, given that they are no longer able to move their hands and arms. Up until now, only a few medical possibilities were able to help at least partially restore the ability to grasp and hold things.

A few years ago, Dr. Rüdiger Rupp from the Paraplegia Centre at the Department of Orthopaedics at Heidelberg University Hospital (Medical Director: Professor Dr. Hans-Jürgen Gerner) started to work on a solution to this problem. During his doctorate, Rupp developed neuroprostheses that can be controlled with weak muscle tension or even with thought power. Rupp was awarded the German Society of Orthopaedics and Orthopaedic Surgery's Konrad Biesalski Prize of €5000 at the German Congress of Orthopaedics and Trauma Surgery, held in Berlin from 22nd to 25th October.

Improving the grasping function considerably improves patients' quality of life

Every year, about 1,800 people in Germany contract paraplegia; 40 per cent of these patients, including many young people, lose the ability to move their arms and legs, in particular the motivity of the arm area. "For severely paralysed patients, any improvement in the ability to grasp an object means a considerable gain in their quality of life and determines whether paralysed patients are able to cope with life on their own or whether they depend on the help of others for their entire life," said Dr. Rupp describing what motivated him to undertake his prize-winning work.

At present, the only way to restore a patient's defective grasping function is by using functional electrostimulation (FES) systems, i.e. neuroprostheses. These devices activate the still intact nerves of the paralysed arm by means of short electrical impulses and – depending on their strength – induce the muscles to contract. In order to achieve a target-oriented grasp movement, many stimulation channels have to be adjusted to work with each other. However, currently available systems are not able to do this to the degree required. Further deficits exist in the user interfaces of neuroprostheses which require the handicapped users to execute somewhat unnatural movements. For example, users need to move their left shoulder in order to control the grasping function of their right hand.

Implantable systems make the use of prostheses easier

Dr. Rüdiger Rupp (Photo: private)

In his doctoral thesis entitled “The motor rehabilitation of paraplegic patients using electrostimulation – an integrative concept for the control of therapy and functional restitution”, Dr. Rupp presents a concept for a device that offers sufficient resources for multi-channel stimulation and the universal implementation of novel user interfaces, using neuroprostheses that can either be implanted or attached to the surface.

“Implantable systems offer a much higher everyday use since grasp patterns can be reproduced and coordinated much more effectively at the same time as being easier to use. But also in cases where implantation is impossible, the surface system can give the user a considerable gain in function,” said Rupp.

Rupp developed two user interfaces and tested their efficiency on patients. He was able to show that electrical signals from very weak arm muscles are particularly suitable for controlling a multi-channel stimulation because it is still possible to use parts of the intact movement control for “natural control”, meaning that patients do not have to go through a long training period to achieve control. In addition, he also provided principle proof that the electrical activity changes resulting from thinking about a certain movement recorded on the head can be used as reference values for grasping neuroprostheses.

Thought control requires a lot of training

“Imagining certain movements leads to characteristic signals in the brain, which a computer can recognise and use to create a specific signal. Even though this thought control requires a lot of training and is very slow, we are aiming to further develop the system in order to be able to provide severely paralysed patients who are unable to move their arms with a neuroprosthesis that will enable them to eat and drink without help,” promises Dr. Rupp. He is hoping that grants from the German Ministry of Education and Research and the EU will help him to achieve this goal in the next few years.

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