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"BrainLinks-BrainTools" – how an intention becomes reality

An accident victim is no longer able to pick up a tea cup because the nerves between the brain and the arm are severed. Researchers from the faculties of biology, medicine and technology at the University of Freiburg are able to translate pure thought into the movement of a cursor on a computer screen. The researchers are part of the BrainLinks-BrainTools consortium, which was recently chosen by the Joint Commission of the German Research Foundation and the German Council of Science and Humanities as a new cluster of excellence at the University of Freiburg, and will over the next five years develop smart solutions in the field of neurotechnology. Their research, which also has the potential to give mobility to patients incapacitated by epilepsy and Parkinson's, is centred on the development of smart brain-machine interfaces.

Electrodes enable the relatively accurate recording of the activity of motor centres in the brain. Insights into the complex electrical patterns of neuronal networks help to anticipate a paralysed patient's intention to carry out a certain movement, translate it into an electrical signal and transfer it to a mouse cursor that can be moved around on the screen by pure thought power. The vision for the future is to develop thought-controlled prostheses.

"To get a robotic arm to reach out to a cup on a table is no trivial matter," said Prof. Dr. Wolfram Burgard from the Department of Intelligent Autonomous Systems in the Department of Computer Science at the University of Freiburg and spokesperson of the BrainLinks-BrainTools consortium which was chosen by the German Federal Ministry of Education and Research (BMBF) as a new cluster of excellence at the University of Freiburg in June 2012. "Our vision is to develop autonomous robotic arms, i.e. physical systems that are able to autonomously work out the position of a cup in relation to the person who wants to pick it up, the strength required to hold it and which cup the person wants to pick up, his or her own or the adjacent cup."

A pacemaker for the brain?

Researchers at the Freiburg University Medical Centre have already made some progress in linking the brain with mechanical and electronic machines. They have carried out investigations in which patients managed to voluntarily control the individual steps of moving a cursor on a screen. However, they have a much bigger goal. The vision is that it will one day become possible for patients to move a prosthesis by simply thinking about a tea cup they can see on a table.

Developments in the field of neurotechnology thus also have the potential to restore mobility to accident victims, stroke

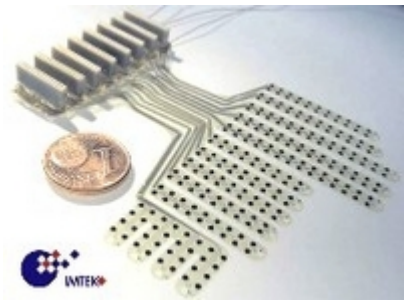
patients and people with other disorders that disrupt motor behaviours that impede arm reaching and hand grasping, for example. Brain-machine interfaces will also be used for many other applications. "We envisage developing smart energy-autonomous brain implants that do not require external energy sources and that are able to bring the uncontrolled brain activity resulting from an epileptic seizure under control. These devices are comparable to cardiac pacemakers in that they work without being perceived by the user," said Burgard. It is further envisaged that deep-brain stimulation implants will in future also help Parkinson's patients to compensate for motor deficits by exciting and inhibiting specific circuits.

At some time in the future it is envisaged that brain implants will be able to prevent epileptic seizures, amongst other things, by way of deep-brain stimulation. (© BrainLinks-BrainTools/University of Freiburg)

Neurology is a relatively young field of research. However, researchers at Freiburg from a broad range of different disciplines, including the fields of biology, medicine, computer science and microsystems engineering, along with their international cooperation partners have already made considerable progress in this field over the last few years. This progress has, amongst other things, become possible due to increasing insights into the neuronal processes on the level of synapses, cells and cell groups obtained using modern molecular and electrophysiological techniques.

The brain is a highly complex network and can also be investigated using theoretical experiments involving computer models and mathematical and bioinformatic tools. This knowledge can then be transferred to experiments involving living cells and cell networks in the Petri dish. In parallel to this work, the researchers at Freiburg have been working in cooperation with small biotech and software companies and big companies and have made progress in the field of technological solutions.

Intelligent neurotechnology and human self-perception



A multichannel electrode like this one might sometime in the future be able to measure a person's movement intentions and transfer them to arm prostheses. (© University of Freiburg)

BrainLinks-BrainTools is specifically focused on optimising the interfaces between the neuronal substrate and the respective effectors, i.e. between neuroprostheses and robotic limbs, for example. In order to do this, multichannel electrode systems or microchips are required, as well as software that helps to filter the flood of data arising from the electrical signals of thousands of nerve cells, interpret them and translate them into output signals. "These interfaces need to be extremely intelligent," said Burgard. "This requires us to implement feedback mechanisms, for example in case the robotic arm picks up the wrong cup or the implant sends too strong signals to certain cells, thus requiring the activity to be readjusted."

Over the next five years, the researchers and industrial partners involved in BrainLinks-BrainTools will use the BMBF funds of €28 million to turn their ideas into reality: new positions will be created for up-and-coming scientists, and interdisciplinary projects, each involving two partners from different fields of research, are being planned. The project also involves ethicians, as interventions into processes in the brain affect human self-perception more than other technologies; they touch on the roots of individuality where the question "am I still myself when a machine controls my brain waves?" might be raised. The researchers will have to deal with such issues. In addition, the researchers plan to engage in a dialogue with the general public, as the issue is a highly sensitive one.

"It goes without saying that we are all very happy about the outstanding award and we are very

much looking forward to starting our work," Burgard said, going on to add "but the award also implies that we have to meet the high expectations being placed on us." The researchers' objective is to tap into new markets for the clinical application of their technology, and this is already evident in the participation of industrial partners in the project. The transfer of technologies from academia to industry also plays a big role. What now remains to be done is to turn the idea into reality. In fact, the researchers have long since started their work: initial progress has been made although no publications have come out of it yet. We can say this much: exciting developments can be expected.

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A contribution from:

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