BRAIN-COMPUTER INTERFACE TECHNOLOGY FOR STROKE REHABILITATION

One of the most common types of Brain-Computer Interface (BCI) systems relies on motor imagery (MI). The user is asked to imagine moving either the right or left hand. This produces specific patterns of brain activity in the EEG signal, which an artificial classifier can interpret to detect which hand the user intended to move. This approach has been used for a wide variety of communication and control purposes, such as spelling, navigation through a virtual environment, or controlling a cursor, wheelchair, orthosis, or prosthesis.

In the last few years, however, a totally novel and promising application for MI-based BCIs has gained great attention. Several recent articles have shown that MI-based BCIs can induce neural plasticity and thus serve as an important tool to enhance motor rehabilitation for stroke patients. In other words, the overall goal of the BCI system is not communication, but improved stroke recovery. Furthermore, other work has shown that this rehabilitation can be even more effective when combined with immersive graphical environments that can help users interact effectively and naturally with the BCI system. Immersive BCI stroke rehabilitation is an ongoing research effort in numerous American and European research projects, many of which involve g.tec.

Much of this work is summarized in a recently published roadmap, which was developed over two years by a consortium of different groups. This roadmap lists BCI for rehabilitation as one of the two emerging disruptive technologies that could dramatically change BCI research. This roadmap is available at future-bnci.org. More information about BCI systems for rehabilitation can also be found under State-of-the-Art in BCI Research (Intec, 2011): BCI Award 2010, which has two sections from Infocomm Research, A*Star, Singapore and Keio University, Japan. Two of the 10 projects nominated for the BCI Award 2010 used BCI systems for rehabilitation purposes.

Neurofeedback is critical in a MI-based BCI. Rehabilitation is most effective when users get immersive feedback that relates to the activities they imagine or perform. For example, if people imagine grasping an object with their left hand, then an image of a grasping hand can help users visualize this activity. If a stroke patient keeps trying to imagine or perform the same movement, while receiving feedback that helps to guide this movement, then users can regain the ability to grasp, or at least recover partial grasp function.

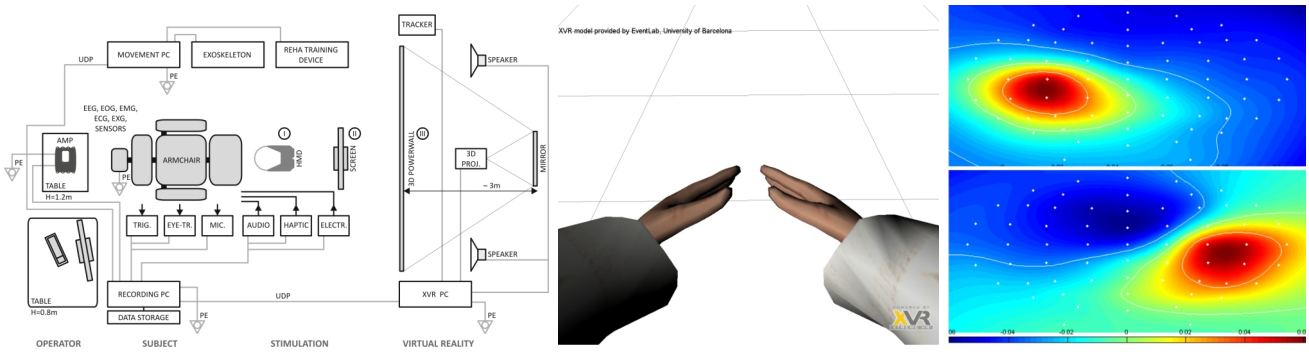

Figure 1: The left panel shows a schematic of a complete BCI laboratory, which could be used as a BCI stroke rehabilitation system. The middle panel shows a virtual feedback environment for stroke rehabilitation. The right panel shows the different common spatial patterns associated with right hand imagination (top panel) and left hand imagination (bottom panel).

Recently, g.tec developed a full research package for stroke rehabilitation. The system consists of a 64 channel cap with active EEG electrodes that are connected to biosignal amplifier g.HIamp. To train the BCI system, the user imagines left and right hand movements. Common Spatial patterns are then calculated from the 64 channels that weight each electrode according to its importance. This electrode selection is done fully automatically and includes algorithms to improve the signal-to-noise ratio. Furthermore, a linear discriminant analysis is trained to distinguish left vs. right hand movements. When this training is finished, which typically takes less than an hour, the patient can control virtual hands that are projected in a highly immersive 3D environment using g.VRsys. Smaller setups can be realized with computer screens or head-mounted devices. This BCI system can also be connected to exoskeletons or rehabilitation training devices. As with all g.tec BCI systems, the BCI stroke rehabilitation system relies on well-known software platforms such as Matlab Simulink, which can easily be interfaced with other components from other sources. For more information, including a list of references or technical details, please contact g.tec.