Brain Computer Interface

Brain Computer Interfaces (BCIs) are intended for enabling both the severely motor disabled as well as the healthy people to operate electrical devices and applications through conscious mental activity. Our approach bases on an artificial neural network that recognizes and classifies different brain activation patterns associated with carefully selected mental tasks. By this means we pursuit to develop a robust classifier with short classification time and, most importantly, a low rate of false positives (i.e. wrong classifications). Figure 1 demonstrates a BCI in use.

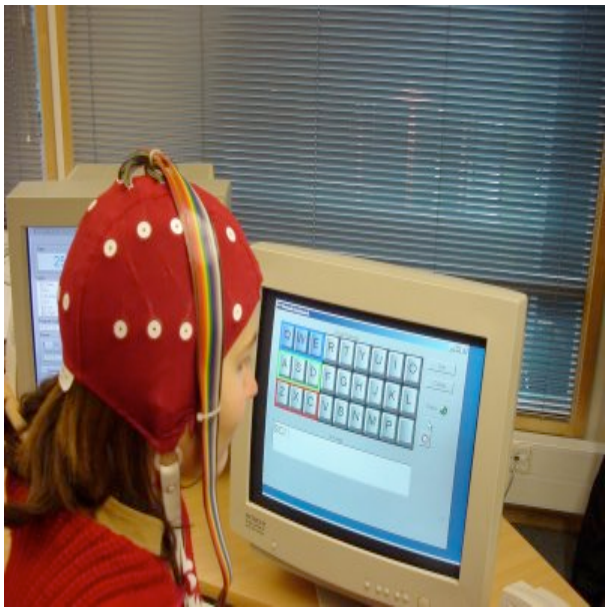

Figure 1. *The user has a EEG cap on. By thinking about left and right hand movement the user controls the virtual keyboard with her brain activity.*

Our group is especially interested in the neurophysiological basis of BCIs. We believe that before the signals can be classified they need to be fully understood. We are especially interested in the activation of the motor cortex. Like most BCI groups, we measure the electric activity of the brain using electroencephalography (EEG). In addition to EEG, we measure the magnetic activity of the brain with magnetoencephalography (MEG). MEG signals are more localized than EEG signals and thus give us more information about the brain activity related to, e.g., finger movements. We study the signals, e.g., using time frequency representations (TFRs) and pick out important features from them. Figure 2 shows an example of a TFR.

Currently we are developing a BCI that measures the signals produced in the brain with magnetoencephalography (MEG). Most BCI groups measure the electric activity of the brain using electroencephalography (EEG). MEG signals are more localised than EEG signals and thus easier to classify. We are extending our research on BCIs to simultaneous EEG and MEG recordings.

Figure 2. *TFR of a MEG sensor on top of the motor cortex. The activation of the brain can be plotted with the time information on the x-axis and the frequency information on the y-axis. The colour scale represents the power of the activation. In this TFR the subject began to move his right finger at time point zero. Strong activation in the 10-30Hz range can be detected after the movement has ended.*

Year 2003

Previously Laboratory of Computational Engineering was involved in EU project called "Adaptive Brain Interfaces". The project came to end at the end of the year 2001. We started our own project called "On-line Adaptive Brain-Computer Interface". The project is part of Academy of Finland's "Research Programme on Proactive Computing" during 2003-2005.

During year 2003 we collected data on attempted finger and hand movements from quadriplegic people using combined MEG and EEG. The research was done in Low Temperature Laboratory in collaboration with Käpylä's kuntoutuskeskus. We have developed a Matlab-based BCI platform for offline as well as online use. The platform is not dependent on measuring device or operating system. It could be used as fast prototyping tool for testing different BCI signal analysis as well as feedback methods. We intend to build online EEG-BCI using this platform and later MEG-BCI. In the field of the signal analysis sequential classification was introduced. Preliminary results show significant improvement over the previous methods used.

TV appearences

The project gained some media coverage when we appeared on television program Prisma on YLE 1 in September 2003. The project is part of Academy of Finland's Research Programme on Proactive Computing till end of the year 2005.

People

This research is led by Academy Professor Mikko Sams and Academy Fellow Jukka Heikkonen. Other persons currently involved are M.Sc. Tommi Nykopp, M.Sc. Janne Lehtonen and Ms. Laura Laitinen. inversion. See more information about the group.

Group's meetings (restricted access).

Additional pictures (restricted access).

Publications

Master's Theses

- Laura Laitinen. Neuromagnetic sensorimotor signals in brain computer interfaces, 2003. (PDF)

- Janne Lehtonen. EEG-based Brain Computer Interfaces, 2002. (PDF)
- Tommi Nykopp. Statistical Modelling Issues for the Adaptive Brain Interface, 2001. (PDF)

BCI links