Leaving the lab: a portable and quickly tunable BCI

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Context and goals

Although many systems for palliative communication based on non-invasive BCIs have been developped during the last few years, very few projects aim at leaving the research labs and hospitals for helping patients at home. Jon Wolpaw's team at the Wadworth Center[1] has developped a portable BCI that has now been used for more than one year on a daily basis by 5 people suffering from ALS. This experiment shows that highly handicaped people greatly benefit from such BCIs that they tend to use during long periods — between 5 an 8 hours a day — for communicating with their loved ones, for surfing the web, or reading and writing emails.

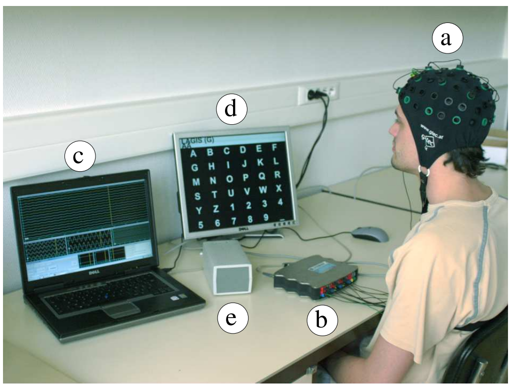
We also aim at being able to leave the lab with this now mature technology for screening handicaped people at home. This would allow checking easily if a patient can use efficiently a BCI without requiring him to come to the hospital or to a specialized laboratory. From the hardware point of view, this home-screening requires a BCI setup that can be used in any situation: portable, fully autonomous and battery powered. From the software point of view, the machine learning techniques that adapt the BCI to the individual must provide a "good" result within a few seconds rather than an "optimal" result after several minutes or hours of processing.

Achievements and future work

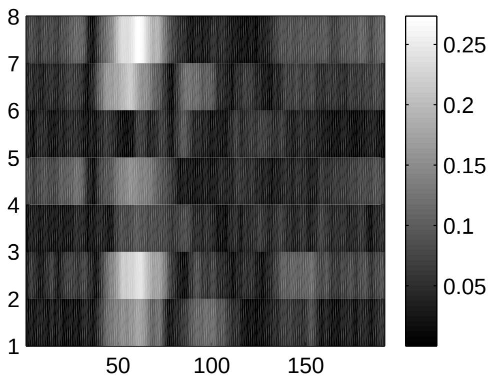
This project started a few months ago, in April 2007 more precisely, and is therefore still under progress. The hardware setup — see figure (1) below — is composed of: (a) an EEG-signal amplifier (Guger Technologies[2] g.USBamp, 16 channels), (b) an EEG-cap, (c) a laptop computer with a dual-core processor for fast signal processing and efficient online classification, and (d) a separate LCD screen, for showing visual feedback to the user. This setup is powered by a battery (e). This system runs the widely used BCI2000 software [2].

A fast learning technique has been implemented for the matrix-based P300-speller paradigm [1]. It computes first and second order statistics of every sample of the EEG signals in the response to a visual stimulus in order to define the most discriminative ones. The pattern presented in figure (2) is a typical result of this learning procedure. The grey level of every sample ($1 \cdots 180$) on every electrode ($1 \cdots 8$) indicates its significance in terms of discrimination between a target and a non-target stimulus. Significant features — for example signal average on small temporal windows — can be determined from these patterns. This approach allows for very fast feature selection — in 2 or 3 seconds in our non optimized implementation — and is therefore well adapted to the home-screening application.

Since these statistics can be computed recursively, requiring a very small computing power, this learning procedure will also be implemented online. The proposed technique is the following: the user spells 3 to 5 characters in copy mode, which yields labeled responses used for the initial classifier training; then the interface is switched to free spelling mode and the online learning procedure adapts the set of features according to the constantly updated statistics. During this step, the operator indicates to the BCI if the letters spelled by the user are correct or not in order to provide a "ground truth" to the learning technique.



(1) hardware setup



(2) classification pattern

References

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[1]Albany, NY, USA. http://www.bciresearch.org/
[2]http://www.gtec.at/