Brain-Computer-Interface Competition

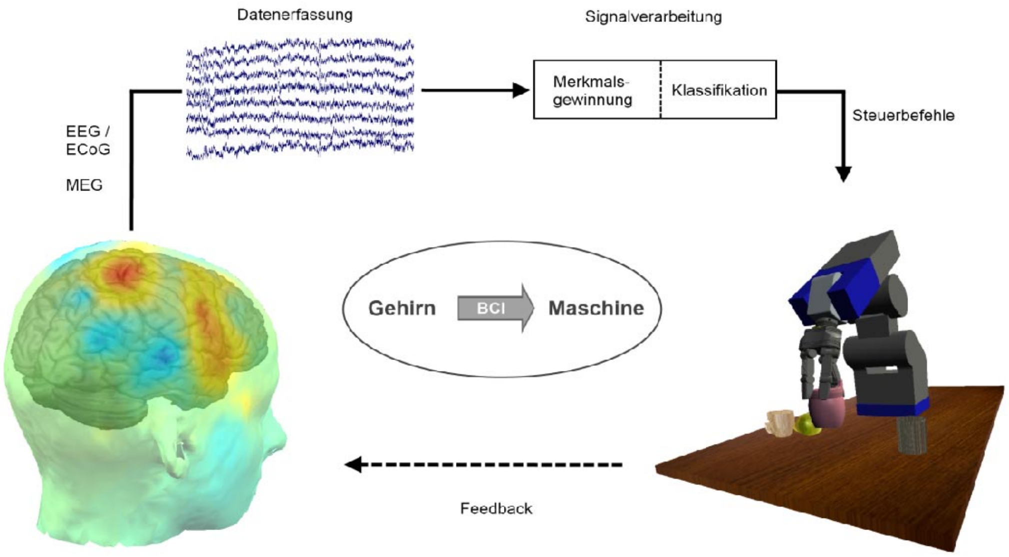
Participate for a chance to win one week winter school with an exciting science and leisure programme.

Background

A few examples of Brain-Computer-Interface (BCI):

- Brain can control prosthesis
- Computer reads mind
- Artificial retina helps blind person
- Machines are controlled directly by the brain

The setup of a typical BCI is represented schematically in the following figure.



Fiction or reality? Research in the field of BCI has shown great potential within the last years and some fictions are already just around the corner:

http://www.youtube.com/watch?v=Y6fug4pzU4Q

Even insight into human visual cognition seems to be possible, as shown an experiment with functional MRI-measurement at the UC Berkeley (cooperation partner of the OvGU):

http://www.youtube.com/watch?v=nsjDnYxJ0bo

The goal of BCIs is the direct communication between human and machines, without the hindrance of motoric interaction. This could be of great assistance for persons with severe disabilities like paraplegia, amputated limbs or paralysis after stroke to retrieve mobility and therefore win back quality of life. Patients suffering from neurological diseases like Amyotrophic lateral sclerosis (ALS, a prominent example being Stephen Hawking) or Locked-in syndrome could use BCIs to communicate again with the outside world.

The first step in realizing BCI is data acquisition. This is typically performed by a measurement of the electrical signals of the brain, by using Electroencephalography (EEG) or sometimes by Electrocorticography (ECoG, see below).Further principles of data acquisition are based on Magnetoencephalography (MEG) or functional magnetic resonance imaging (fMRI).

The measured data is then pre-processed and fed to the analysis computer. The main challenge has been located at this point in the BCI process. This analysis is crucial in the interpretation of the patient's intent, such as a specific movement. So far, no reliable and non-ambiguous solution strategy has been determined. The research in this field depends on creative and intelligent ideas.

At this point we come to the challenge: We would like to encourage every student who is interested in science, with a little bit of experience in programming, to join this competition. Knowledge about signal-processing and classification is helpful but not necessary. We are looking forward to each contribution.

The analysis of the signals of the brain offers the potential to generate control-commands for different applications. For instance, this could be a spelling-computer. [1] In 2004 ECoG data was used for the first time to control a cursor on a monitor (one-dimensional). [2] Further studies showed that it is also possible to control an arm-prosthesis with this method.[3]

Task

The task of this challenge is to decode the effective patient movement from the acquired brain-signals of a test subject. For this, real ECoG brain-signals are provided. These electrical voltage signals were measured directly at the surface cerebral cortex (sensori-motor cortex). For the acquisition of these signals, the cranium of the patient is opened and an electrode-grid is placed on the surface of the brain. Subsequently, the skull is closed again. [4] In contrast to the EEG, which is measured by electrodes located on the scalp, the advantage of the ECoG-data is better temporal and spatial resolution, as well as better signal-to-noise-ratio.

Award

The participants with the best solution have the opportunity to take part in a winter school free of charge and complete an interesting scientific program. Winter sports and other amusement will not be missed out.

Process

An ECoG-dataset (anonymized and split in two parts – training and test block) will be provided. In the training-block the corresponding movement of the fingers are published in addition to the ECoG dataset. In the test-block only ECoG-signals are provided.

Access to the data is provided after request via email. Therefore each participant must agree that the data will not be shared with others or used for anything other than the intended purpose. This takes

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[1] For the first time ever published in Nature in 1999: „A Spelling device for the paralyzed“ by Birbaumer et al.

[2] Published in: Journal of Neural Engineering: „A Brain-Computer Interface using electrocorticographic signals in humans“ by Leuthardt et al.

[3] Published in: Annals of Neurology: „Electrocorticographic Control of a Prosthetic Arm in Paralyzed Patients“ by Yanagisawa et al., s.a.: http://onlinelibrary.wiley.com/store/10.1002/ana.22613/asset/supinfo/ANA_22613_sm_SuppVideo3.mov?v=1&s=72ee1167d2c6aaa835d76b313349b479d84c77f5

[4] Da data were acquired from epilepsy patients, who do not respond to medication. Some of them can be treated by the removal of the provoking brain-regions. As a first step for this, the determination of the affected region must be carried out, in parts by ECoG measurements. These patients were volunteering for studies for the BCI-research by executing simple tasks.

place in the form of a signed letter of agreement (→ Link) and handed in at the registry G09-323 or G09-326 to Ms. Köpke. (7.30am to 4pm)

The task is to develop a method using the training block to identify the correct finger-movement from the ECoG signal and to evaluate this method using the test-block.

1. Two months are available to solve the problem
2. The following documents must be handed in via email:
    - A short summary (less than one page) including your personal data
    - Classification of the finger (labels) to the time segment (trails) in the test-data
    - Source code of the developed software (free choice of the programming language)
3. The assessment of your solution will be carried out by a jury composed of Professors, Research Assistants and Students. If necessary we will invite you for a short discussion about your work.
4. Publication of the correct solutions and winners will take place on the 1st of December 2012.

Facts

- Duration of the competition: 1st of August 2012 until the 1st of October 2012
- Publication of the winner: 1st of December 2012
- Award: Fully funded participation in the winter school (February/March 2013)

Who can participate?

Each student of a Bachelor-/Master or Diplom degree programme of the Otto-von-Guericke-University Magdeburg.

It is also possible to compete in teams of two if it is clear that both candidates have an equal contribution in the result.

Each participant must agree that the data will not be shared with anyone else or used for anything other than the intended purpose. Violation will lead to disqualification

Contact person

Contact: Tim Pfeiffer, Robert Frysch

Via email to → sw4g.production@gmail.com or directly in G09-312.

For all interested students, we will provide a short consultation on 08.08.2012 at 4.15pm. For further question or suggestions, please contact us via email.

Latest news → http://www.iesk.ovgu.de/BCI_Competition

Who wins?

1. The solution with the highest recognition-rate
2. The most elegant/creative solution (Jury's decision)

Information about the paradigm

The test persons were directed to push a specific button on the keyboard as fast and precise as possible. This request was conveyed on a small screen. The subjects were requested to use their thumbs, forefingers, middle fingers and little fingers. The fingers rest on a laptop-keyboard in touch typing position between the commands. Only the right hand was used. The ECoG data of the dedicated cerebral hemisphere (left) was acquired continuously.

Data format

The provided data has already been trimmed in sectors of 2 seconds and centered around the keypress (the so-called trials).

In the pre-processing step the so-called baseline is already removed, i.e. the mean of one trail is already subtracted from each sample. This leads to an average of zero for each channel of all trials.

The ECoG-data is acquired with 64 channels with a sampling frequency of 1017.3 Hz.

Regarding the ECoG data of the training-block the following classification is provided:

1 – Thumb
2 – Forefinger
3 – Middle finger
4 – Little finger

The data is provided as a binary file. Upon request different file formats such as ASCII may also be provided.

ECoG-data

Structure: 3-dimensional array with the dimensions:

- Channel number (Electrode)
- Trial number (Keypress)
- Sample number (Timestep)

Endianness: Little-Endian, 32-Bit floating point

The data is organised in the following 3D-structure, which appears out of the following pseudo-code (import of the data).

```
For c = 1 to 64 (channelnumber)
{
   For t = 1 to 238 (trialnumber)
   {
      For s = 1 to 2034 (samplenumber)
      {
         Data[c][t][s] = readFloat32(file)
      }
   }
}
```

The (1D-)index (of sample *s* of trial *t* of the channel *c*) of the 3D-structure then can be calculated as follows:

```
Index(c,t,s) = s + (t-1)*2034 + (c-1)*2034*238;  c,t,s = 1,2,…
```

Label-data

Structure: 1-dimensional field with the trial number as dimension

The label-data is stored in a block of 32-bit (integer)

Pseudo-code for import of the data:

```
For t = 1 to 238 (trialnumber)
{
   Label[t] = readInt32(file)
}
```

Model implementation

MatLab → Link

C → Link

C++ → Link

Hosted by Chair for Healthcare Telematics and Medical Engineering
Prof. Dr. Georg Rose
Faculty for ET & IT

In cooperation with the Hospital for Neurology of the University Hospital of the OVGU
Prof. Dr. H. Hinrichs

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