Five current challenges for BCI standards

Rupert Ortner, g.tec medical engineering
Research projects

H2020 SME project: recoveriX - motor recovery after stroke

H2020 SME project: ComaWare – coma assessment and communication

H2020 Eurostars project: ComAlert – coma prediction

H2020 Eurostars project: RapidsMaps – high gamma mapping

EC project: Neurographene – development of Graphene electrodes

EC project: ReNaChip - Rehabilitation of a discrete sensory motor learning function

EC project: Sm4all – Smart Home for all

EC project: RGS – Rehabilitation Gaming System faster recovery from stroke

EC project: BrainAble - BCI with VR and social networks

EC project: Decoder - BCI for locked in patients

EC project: CSI - Central Nervous System Imaging

EC project: BETTER – BCI for Stroke rehabilitation and rehabilitation robots

EC project: VERE – Virtual Embodiment Real Embodiment

EC project: ALIAS – Adaptable Ambient Living Assistant

EC project: BACKHOME – BCIs for end users

EC project: DENECOR

EC project: High Profile
A BCI Lab
Challenge 1: Different sensors

• Non-invasive versus invasive (different regulations, FDA, CE)
• Depth electrodes, grids versus EEG electrodes
• Active or passive electrodes
• Gel or dry EEG electrodes
• Different number of channels (P300: 8, SSVEP: 8, motor imagery: 64, invasive mapping: 256)
• Different sampling frequency (Spikes: 40 kHz, ECoG: 1-4 kHz, EEG: 256 Hz)
• Different platforms (Windows, Linux, Android,...)
How to interface an amplifier

- **g.NEEDaccess** service to interface all amplifiers with one common interface
  - A. C++ Application Program Interface (API)
    - integrate amplifiers into own software under Windows and Linux
  - B. MATLAB API
    - integrate amplifiers into MATLAB data acquisition and analysis programs
    - access all toolboxes (Signal Processing, Neural Networks, …)
    - access user written M-files
  - C. Simulink Highspeed on-line Processing
    - amplifier device driver block under Simulink
    - copy the block into Simulink model and connect it with S-functions and paradigm blocks
    - just exchange the amplifier device driver and work with the same signal processing blocks
  - D. LabView
    - amplifier device driver block under LabView
    - use standard LabView blocks for analysis

- All options provide full access to hardware
  - bandpass, notch settings
  - sampling frequency
  - impedance check
  - synchronization with digital inputs for synchronization
  - direct integration of other devices
Challenge 2: Event Timing

Real-time data stream synced with external devices
visual P300: 1 ms resolution
vibro-tactile P300: 1 ms resolution
....

Control of external devices
UDP
digital outputs
Embodiment station

Stimulate the body and observe effects in the brain -
- real-time functional mapping
Stimulate the brain and observe effects on the body
- real-time sensing

Aim: Build a functional cortical atlas.

cortiQ - Clinical software for electrocorticographic real-time functional mapping of the eloquent cortex.
Prueckl R, Kapeller C, Potes C, Korostenskaja M, Schalk G, Lee KH, Guger C.
Rapid cortical mapping

Exclude bad channels from signal processing.
Challenge 3: Many controllable elements

- Smart home needs many controls for domotic devices
- BCI has to understand which controls are necessary
- BCI must be updated to changes of the environment
ACTOR protocol

- The BCI speaks with ACTOR protocol with the avatars and robotic systems
- **XML files** are loaded at startup (from disk or from a text string, which is received over the network)
- Updates of the XML files can be received at runtime over UDP: **Modify the contents of the BCI at runtime**, e.g. to achieve context awareness
Challenge 4: Avatar/robot control

• The person is seeing the environment through the avatar or robotic system
• We need BCI controls for controlling the avatar/robot
• The BCI system has to send control command to external system
• Interfacing with rehabilitation devices
Screen overlay control interface - SOCI
## Challenge 5: Performance standards

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<thead>
<tr>
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<tbody>
<tr>
<td>Grand average accuracy</td>
<td>87 %</td>
<td>98 %</td>
<td>100 %</td>
</tr>
<tr>
<td>Training time</td>
<td>30 min</td>
<td>5 min</td>
<td>5 min</td>
</tr>
<tr>
<td>Number of electrodes</td>
<td>32</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Random classification accuracy</td>
<td>½</td>
<td>¼</td>
<td>1/36</td>
</tr>
<tr>
<td>Decision time for selection</td>
<td>6 sec</td>
<td>3 sec</td>
<td>About 45 sec with 15 flashes</td>
</tr>
<tr>
<td>Location</td>
<td>Motor cortex</td>
<td>Visual cortex</td>
<td>Central line and visual cortex</td>
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