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Five current challenges for BCI standards

Rupert Ortner, g.tec medical engineering


MOZART


Musical
Empress
Elisabeth


Emperor‘s castle

Northwestern Passages
Kalaallit Nunaat Greenland
Hudson Bay
North Atlantic Ocean
Gulf of Mexico
Caribbean Sea
Cuba
Puerto Rico
Guatemala
Nicaragua
United States
Ireland
Éire
United Kingdom
Sweden
Norge
Norway
Danmark
Denmark
Polska
Poland
Deutschland
Germany
Беларусь
Belarus
Україна
Ukraine
France
Österreich
Austria
România
Romania
Italia
Italy
España
Spain
Portugal
Ελλάς
Greece
Türkiye
Turkey
Tunisia
Morocco
Algeria
Western Sahara
Mali
Niger
Iraq
Iran

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

Ⓐ g.MOBIlab+ ☐ EEG version ☐ multi-purpose version

☐ g.GAMMAcap

☐ Consumables

Electrodes ☐ active ☐ passive ☐ dry

Ⓑ g.USBamp ☐ 16 channels ☐ 32 channels ☐ 48 channels ☐ 64 channels

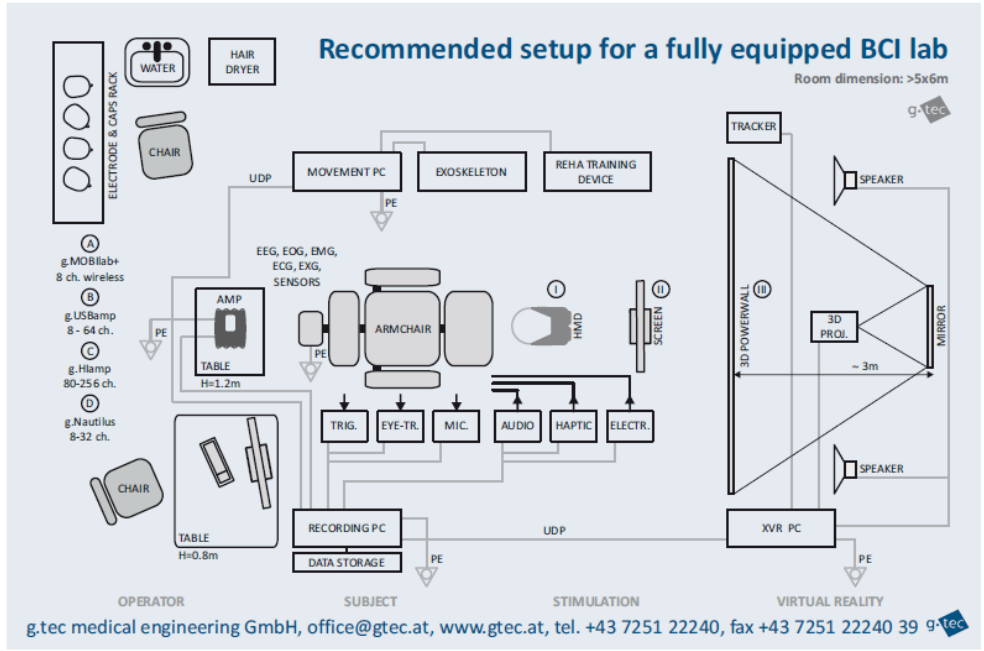
Ⓒ g.Hlamp ☐ 80 channels ☐ 144 channels ☐ 256 channels

Ⓓ g.Nautilus ☐ active-gel ☐ active-dry ☐ 8 channels ☐ 16 channels ☐ 32 channels

☐ Eyetracker (screen-mounted) ☐ Eyetracker (head-mounted)

Recommended setup for a fully equipped BCI lab

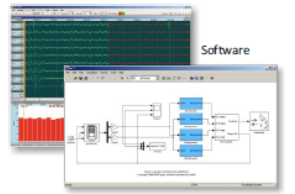
Room dimension: >5x6m



g.tec medical engineering GmbH, office@gtec.at, www.gtec.at, tel. +43 7251 22240, fax +43 7251 22240 39

☐ Impedance tester ☐ Signal generator

☐ VR-system



Software

Sensors ☐ GSR ☐ Blood pressure ☐ Respiration ☐ Temperature ☐ Pulse ☐ Acceleration ☐ More sensors

☐ Electrical stimulator

☐ g.STIMbox ☐ g.SSVEPbox

☐ g.Recorder ☐ g.BSanalyze ☐ g.Hlsys (Simulink) ☐ g.Hlsys (LabVIEW) ☐ intendiX ☐ BCI2000 ☐ C/MATLAB/Linux API ☐ g.RTanalyze ☐ g.PHYSIOobserver ☐ g.UDPinterface ☐ mindBEAGLE ☐ cortiQ ☐ Eyetracker interface ☐ g.NEEDaccess

Examples ☐ P300 ☐ Motor imagery ☐ SSVEP ☐ CSP/RehaBCI ☐ Vibro-tactile P300 ☐ Ping-Pong game ☐ Hyperscanning ☐ Hybrid BCI ☐ EMG/EOG control

Training material ☐ EEG lecture ☐ EP lecture ☐ BCI lecture

Request an offer for a complete lab ☐ minimum ☐ basic ☐ advanced

Check products of interest and request an offer per fax (+43 7251 22240 39) or e-mail (office@gtec.at) !

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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,…)

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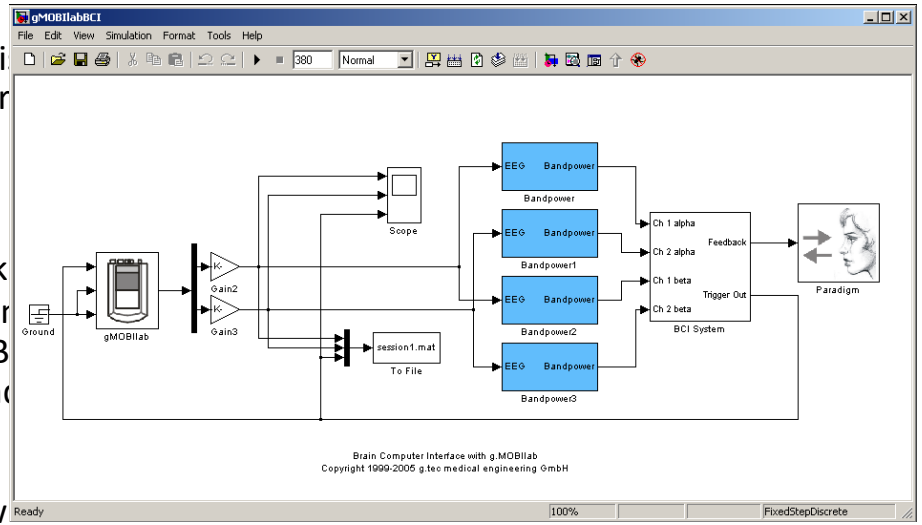
How to interface an amplifier

- **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 acqui
    - access all toolboxes (Signal Processing, Neur
    - access user written M-files
-
- C. Simulink Highspeed on-line Processing
    - amplifier device driver block under Simulink
    - copy the block into Simulink model and conn
    - (S-functions) and paradigm blocks (MATLAB
    - just exchange the amplifier device driver an
      processing blocks
- D. LabView
    - amplifier device driver block under LabView
    - use standard LabView blocks for analysis



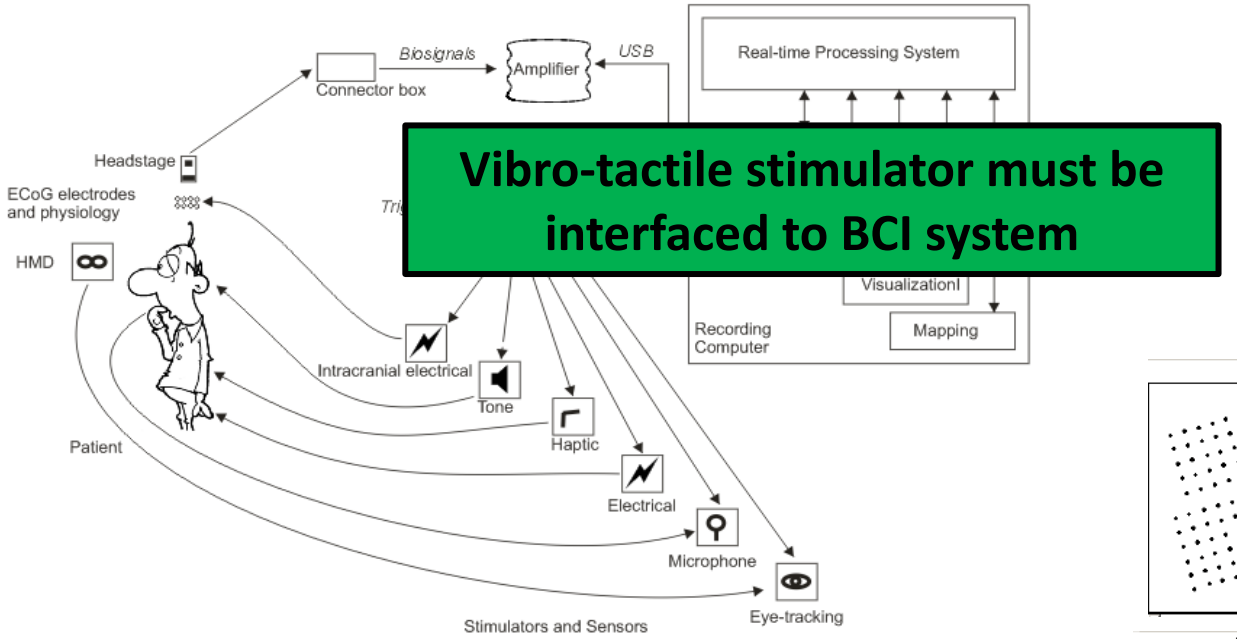
- *All options provide full access to hardware*
    - bandpass, notch settings
    - sampling frequency
    - impedance check
    - synchronization with digital inputs for synchronization
    - direct integration of other devices

Challenge 2: Event Timing

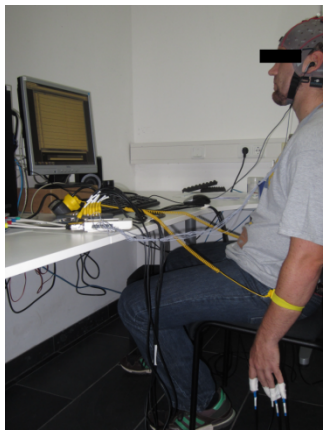
Real-time data stream synced with external devices
- visual P300: 1 ms resolution
- vibro-tactile P300: 1 ms resolution
- ….

Control of external devices
- UDP
- digital outputs

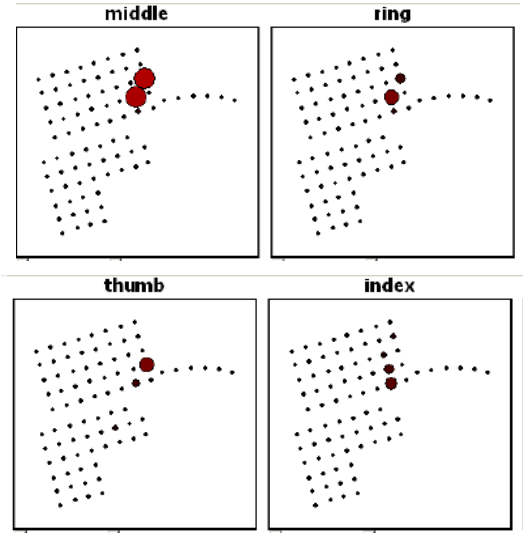
Embodiment station



Vibro-tactile stimulator must be interfaced to BCI system



VERE



Gerwin Schalk, Wadsworth Center

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.
Conf Proc IEEE Eng Med Biol Soc. 2013 Jul;2013:6365-8. doi: 10.1109/EMBC.2013.6611010.

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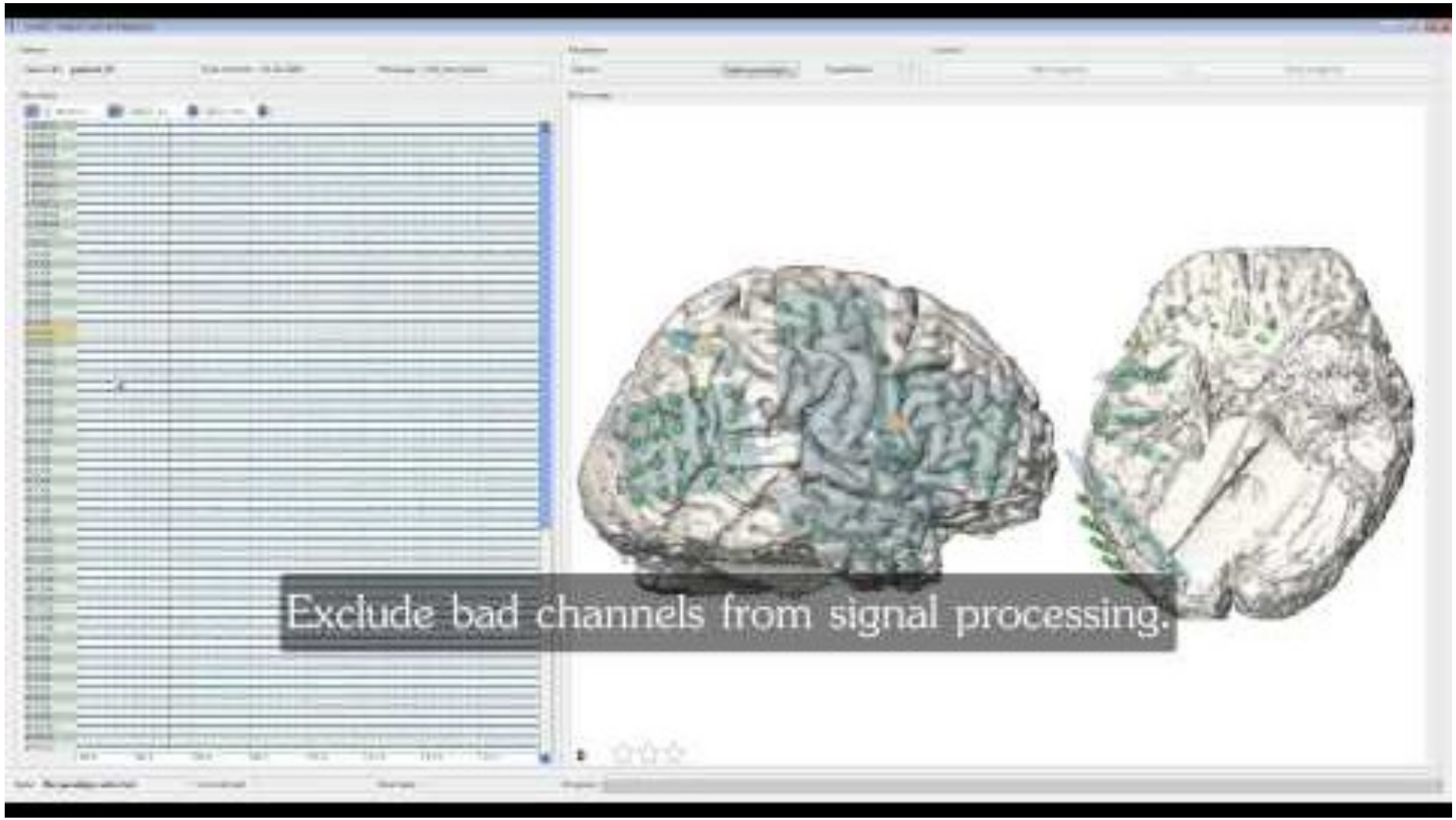
Rapid cortical mapping

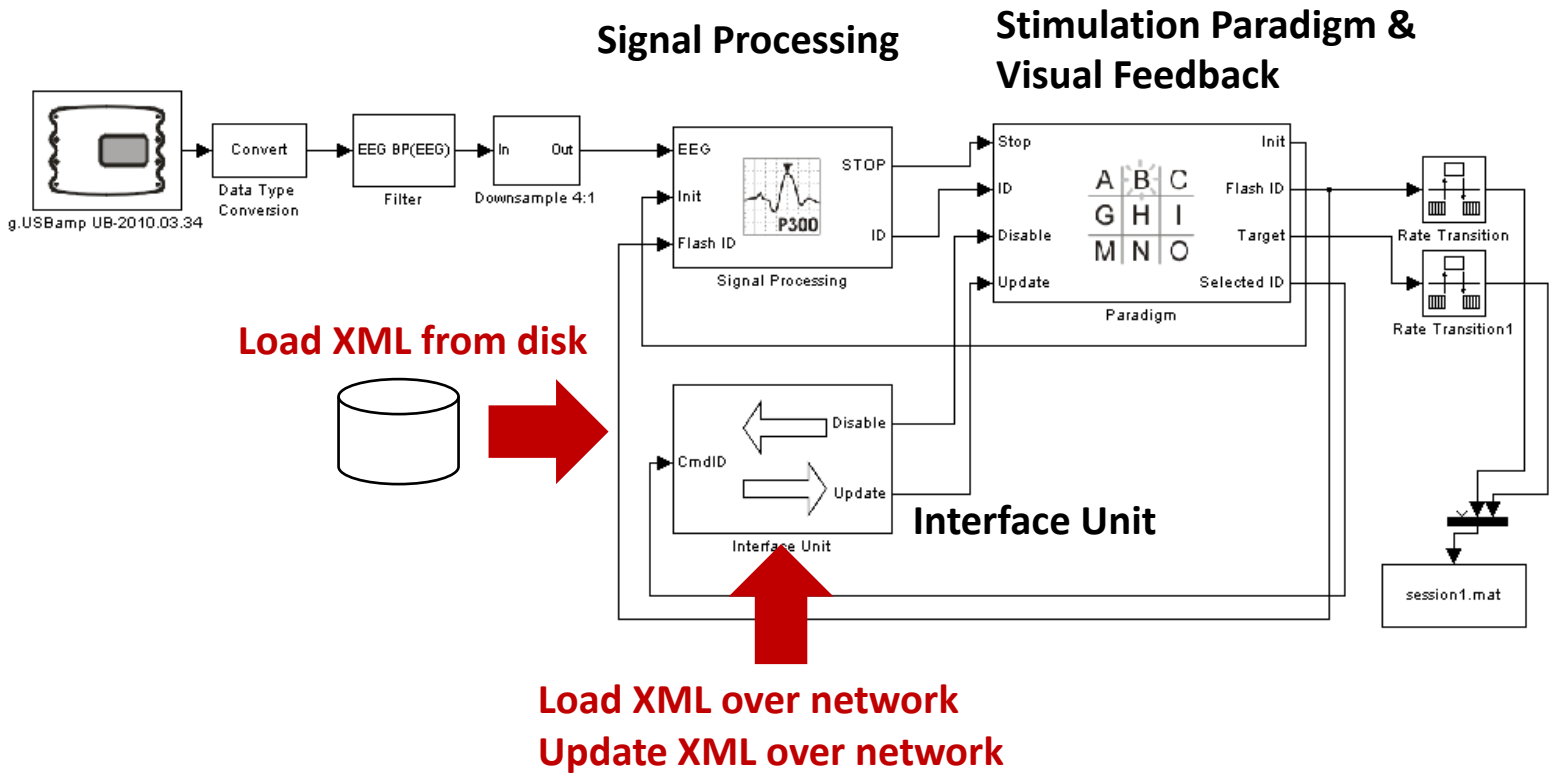


Challenge 3: Many controllable elements

- 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



C. Hintermüller, C. Kapeller, G. Edlinger, C. Guger (2013): "BCI Integration: Application Interfaces" Book Article in "Brain-Computer Interface Systems – Recent Progress and Future Prospects" R 44879, Intec, book chapter

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

	Motor imagery N=5 [Irimia 2016]	**cVEP N=18 [Kapeller]**	**P300 speller [Guger 2016]**
Grand average accuracy	87 %	98 %	100 %
Training time	30 min	5 min	5 min
Number of electrodes	32	8	8
Random classification accuracy	½	¼	1/36
Decision time for selection	6 sec	3 sec	About 45 sec with 15 flashes
Location	Motor cortex	Visual cortex	Central line and visual cortex

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