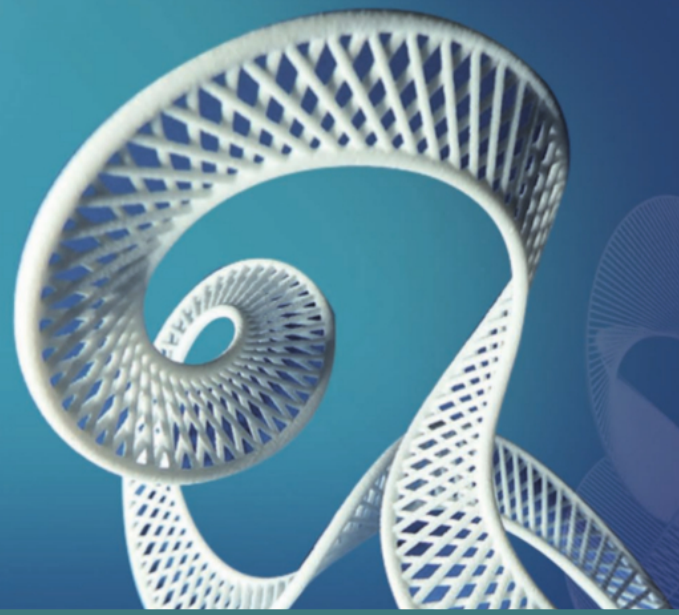
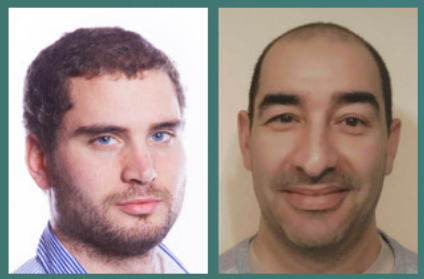
CRIStAL



Hybrid BCI for people with Duchenne muscular dystrophy

François Cabestaing

Rennes, September 7th 2017



Brain Computer Interfaces

BCI timeline

- 1929 - Electroencephalogram (Berger)
- 1965 - Discovery of cognitive evoked potentials (Desmedt & Sutton)
- 1973 - Brain–computer interface concept (Vidal)
- 1988 - First BCI using evoked potentials (Farwell & Donchin)
- 1991 - First BCI allowing a continuous 1D cursor control (Wolpaw)
- 2004 - 2D electrode matrix implanted in the motor cortex (BrainGate & Donoghue)
- 2010 - Hybrid Brain–computer interface (Pfurtscheller)
- 2015 - Exoskeleton for people with tetraplegia, Wimagine implant (Benabid)


Berger


Desmedt


Vidal


Donchin


Wolpaw

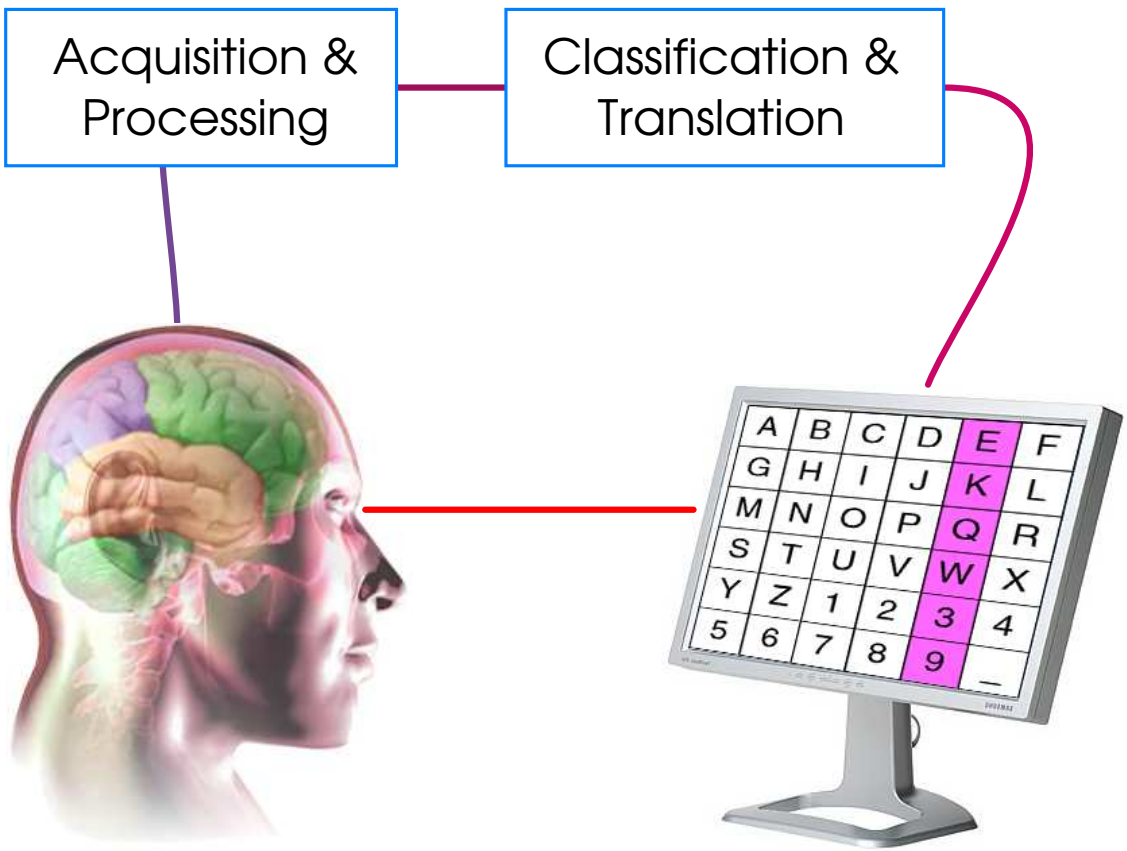

Donoghue


Pfurtscheller

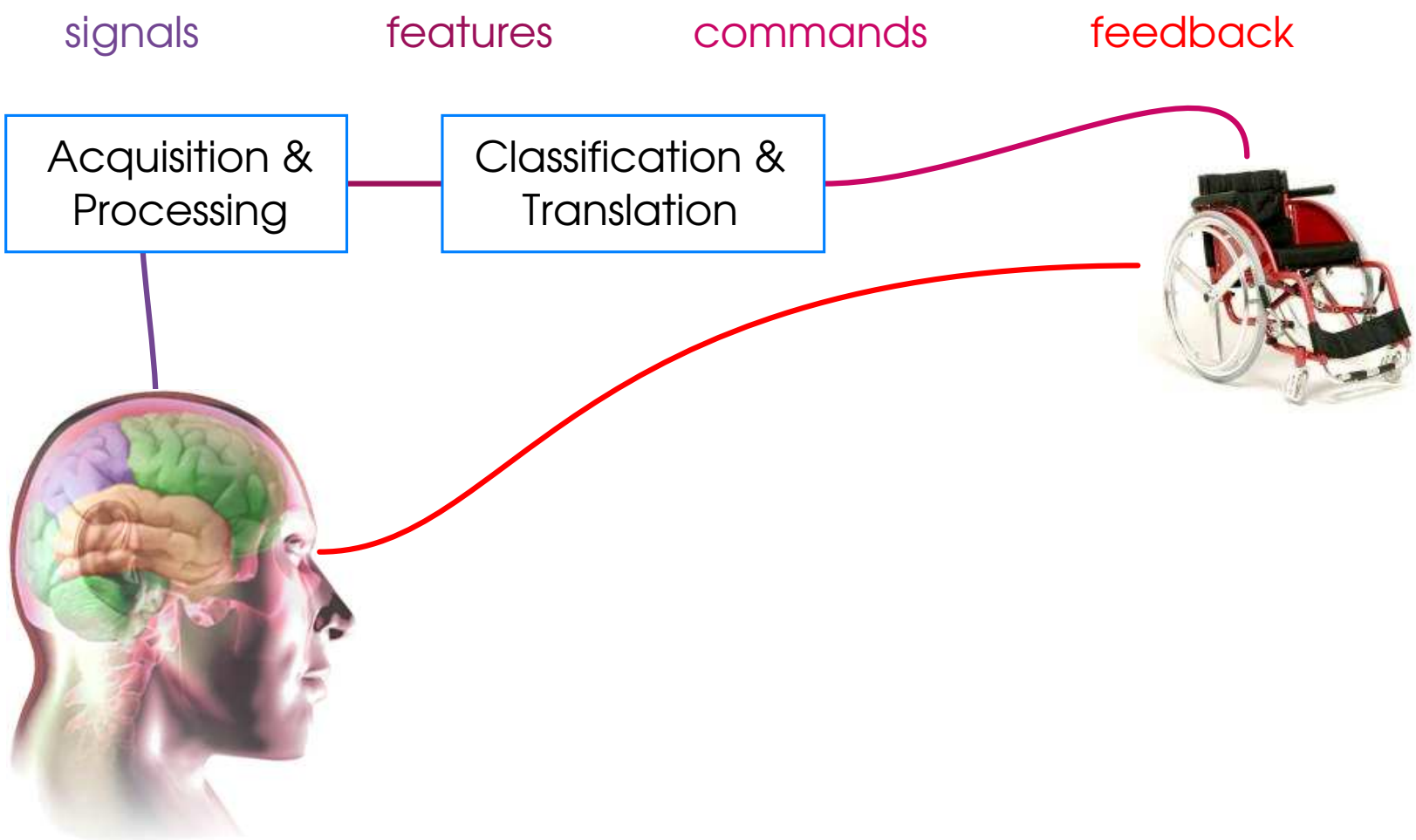

Benabid

hybrid BCI: several modalities or other inputs

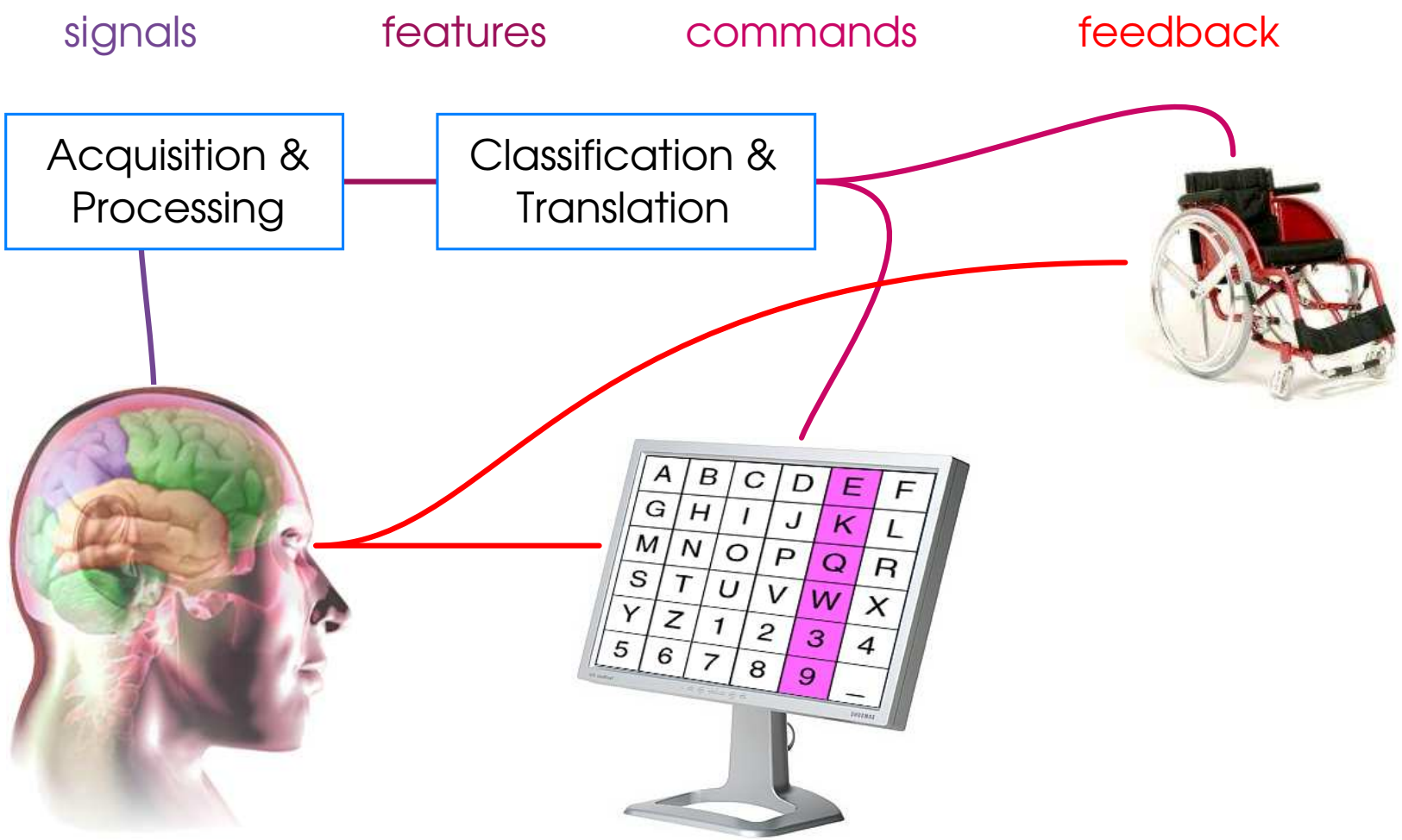
signals features commands feedback



hybrid BCI: several modalities or other inputs

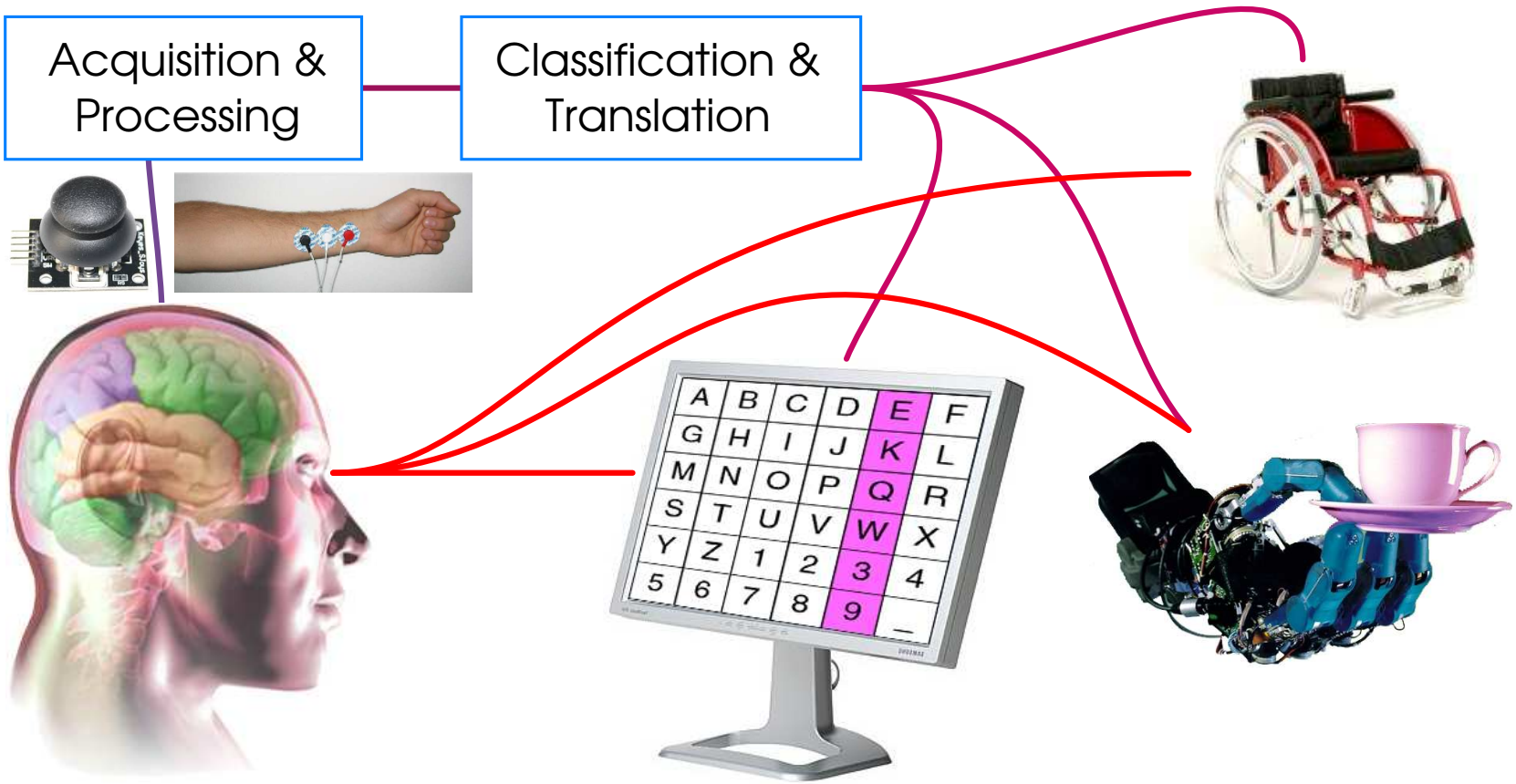


hybrid BCI: several modalities or other inputs



hybrid BCI: several modalities or other inputs

signals features commands feedback



state of the art – 2013, 13 articles

Hindawi Publishing Corporation
Advances in Human-Computer Interaction
Volume 2013, Article ID 187024, 8 pages
http://dx.doi.org/10.1155/2013/187024

Review Article

A Review of Hybrid Brain-Computer Interface Systems

Setare Amiri, Reza Fazel-Rezai, and Vahid Asadpour

hybrid BCI taxonomy

- simultaneous: both modalities are used simultaneously to increase throughput and/or information accuracy
- sequential: one modality controls the other (for instance: activation or deactivation)

combination

- of two BCI interaction modalities: ERD/ERS, P300, SSVEP
- of two brain activity measurement methods: EEG, fNIRS
- with other signals not coming from brain: EOG, EMG, motion, etc.

state of the art – 2017, 74 articles


PLOS ONE

COLLECTION REVIEW

A systematic review of hybrid brain-computer interfaces: Taxonomy and usability perspectives

Inchul Choi[1☯], Ilsun Rhiu[2☯], Yushin Lee[3], Myung Hwan Yun[3], Chang S. Nam[1*]

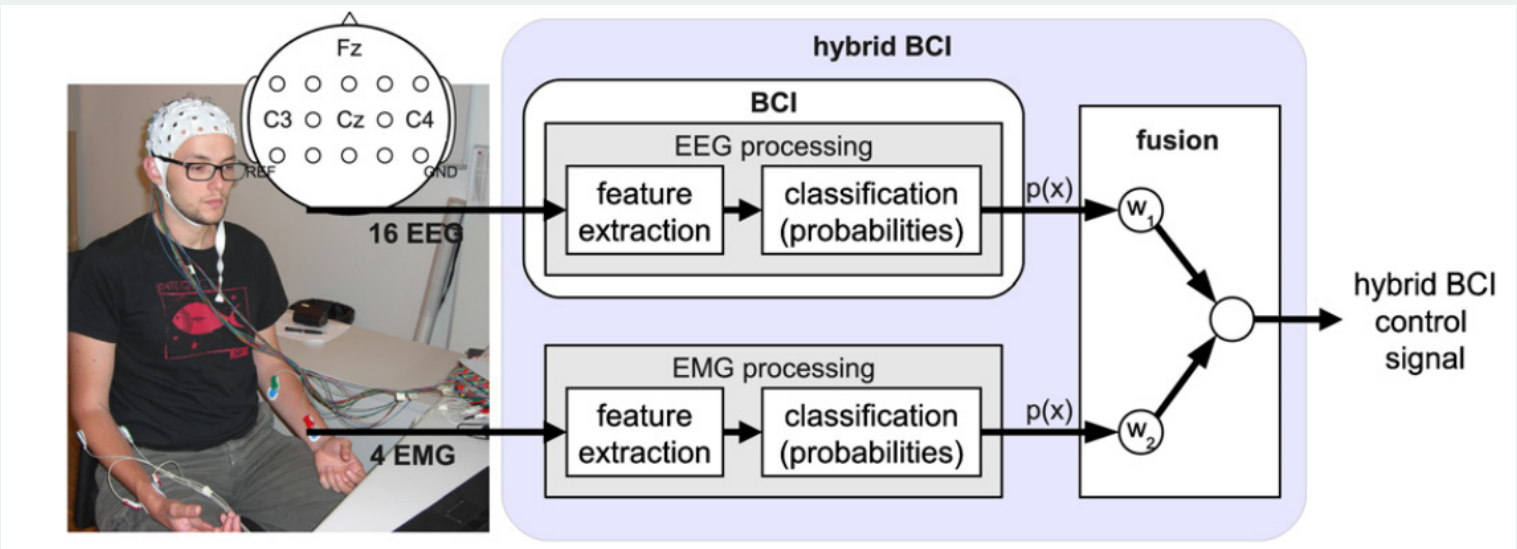
summary of signal combinations

Type	Input signals		# of studies (%)
Single brain signal	EEG	EEG	44 (59%)
Several physiological signals	EEG	EOG	6 (8%)
	EEG	EMG	3 (4%)
	EEG	EKG	2 (3%)
Brain signal and other input(s)	EEG	Gaze tracking	11 (15%)
	EEG	Joystick	2 (3%)
	EEG	Gyroscope	1 (1%)
Several brain signals	EEG	fNIRS	6 (8%)

hybrid BCI, with EEG and EMG

state of the art

- Riccio *et al.*: Hybrid P300-based brain-computer interface to improve usability for people with severe motor disability: electromyographic signals for error correction during a spelling task.
- Lin *et al.*: An online hybrid BCI system based on SSVEP and EMG.
- Leeb *et al.*: A hybrid brain–computer interface based on the fusion of electroencephalographic and electromyographic activities.



hybrid BCI for DMD patients

Duchenne muscular dystrophy

- the most severe dystrophinopathy, affects about one in 5,000 males at birth
- first clinical symptoms begin around 2/3 years, wheelchair at 12, ...
- but ... life expectancy has doubled in the last 20 years!

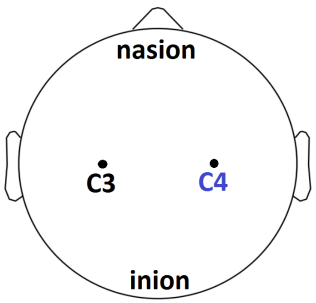
long term motor handicap

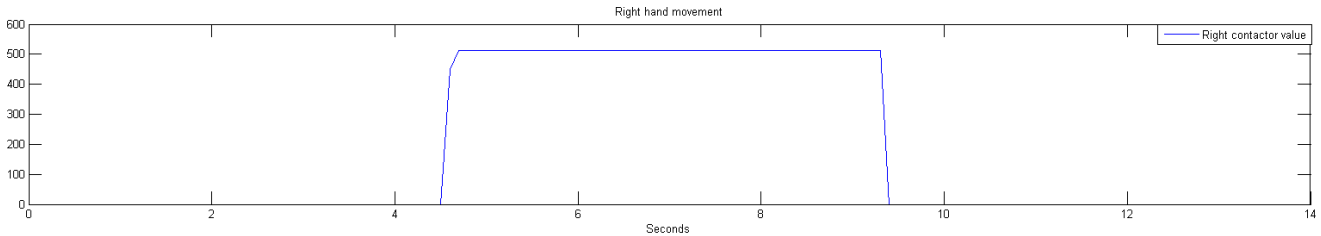
- better medical care has increased life expectancy, and therefore the duration of severe motor handicap situation has also increased
- current assistive technologies: micro-joysticks, gaze-trackers, etc.

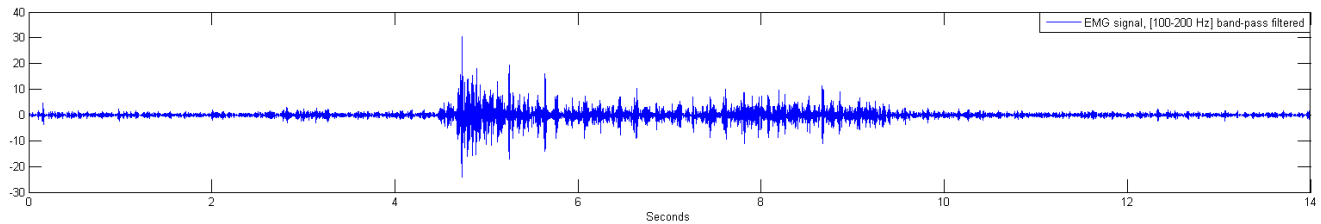
our proposed approach

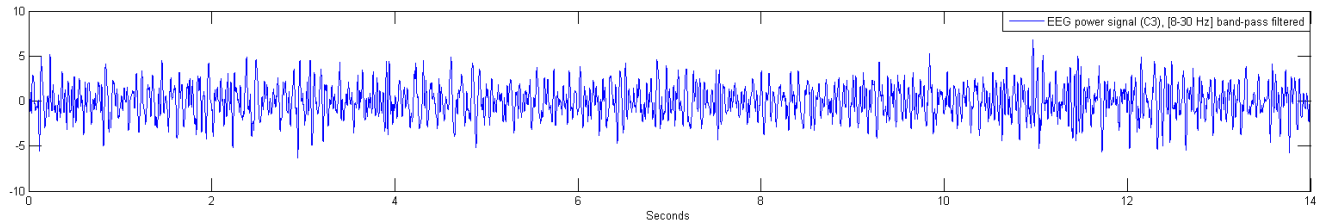
- hybrid BCI: joysticks + EMG + EEG
- fusion of control signals, according to patient state, short or long term variations
- control strategy: left and/or right hand movements

joystick, EMG and EEG signals









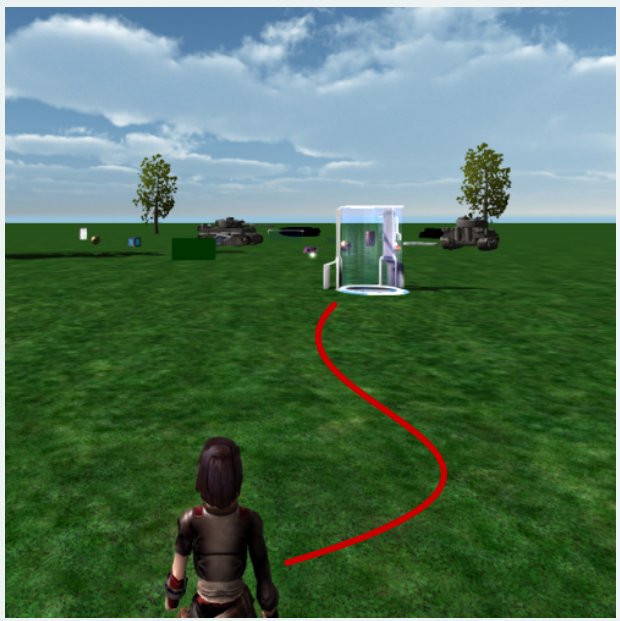
CRIStAL
Centre de Recherche en Informatique, Signal et Automatique de Lille

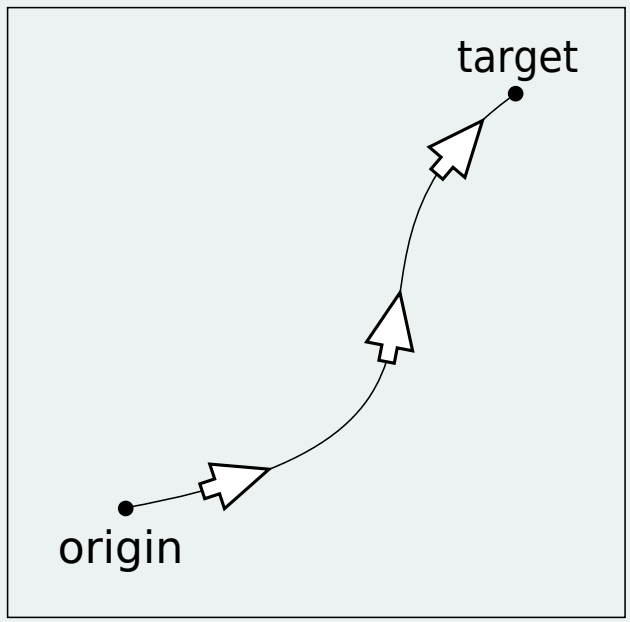
trajectory control

elementary actions

- 3 actions: left hand, right hand, both hands simultaneously
- 3 controls: turn left, turn right, go straight

trajectory vs. cursor control





user training: video game

karting

display of virtual hands

maze

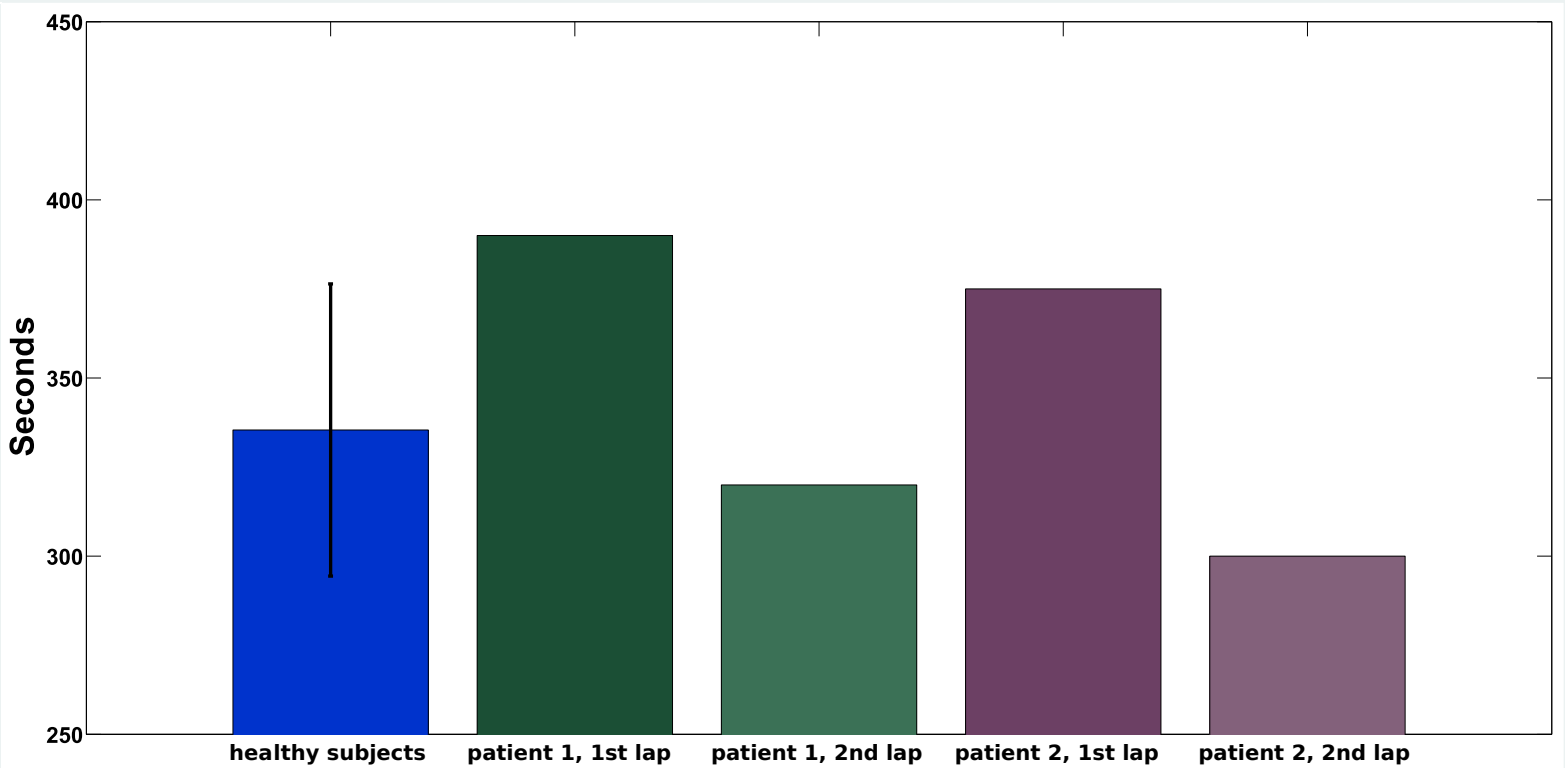
cursor control

pilot study: 2 DMD patients vs. 10 healthy subjects

control of a video game: karting

pilot study: 2 DMD patients vs. 10 healthy subjects

time to finish a lap (control by EMG only)



thank you ...