Brain-Machine Interface Systems Lab

Miguel Hernández University of Elche, Spain

Projects & Research Lines

José M. Azorín, PhD

http://bmi.umh.es

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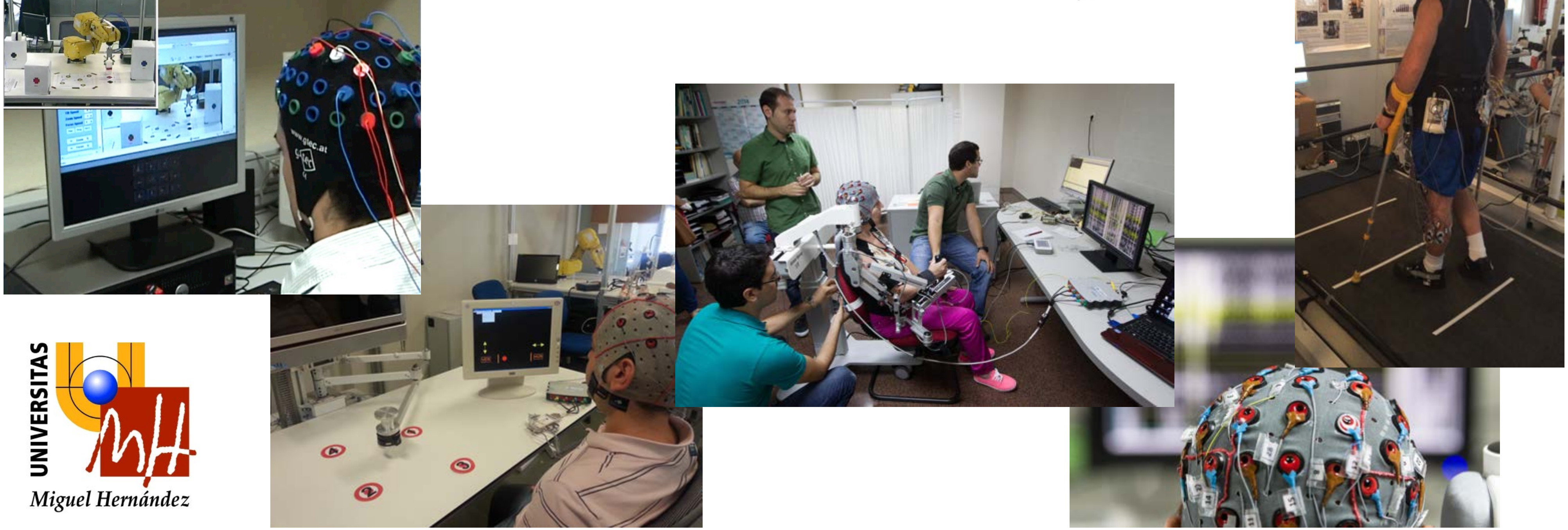

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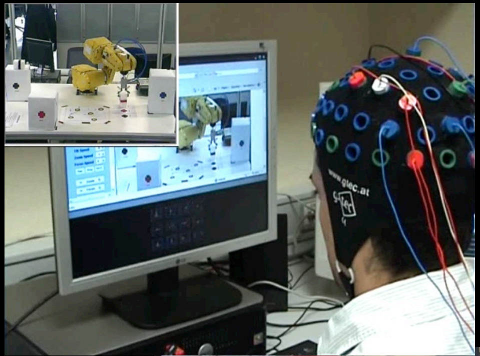
Projects & Research Lines

- Coste4Dis
  - Evoked BMI
- Communication system of basic needs
- Brain2Motion
  - BMIs for upper limb exoskeletons
  - Spontaneous BMIs
  - Detection of movement intention
  - Kinematics decoding from EEG
  - BMI & EOG interface
- BioMot
  - Cognitive mechanisms during walking
- Associate



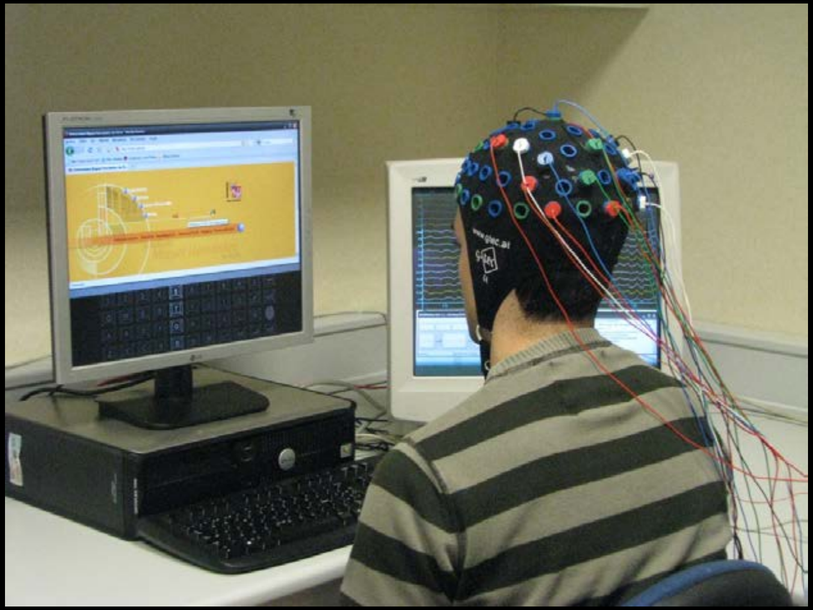
Coste4Dis

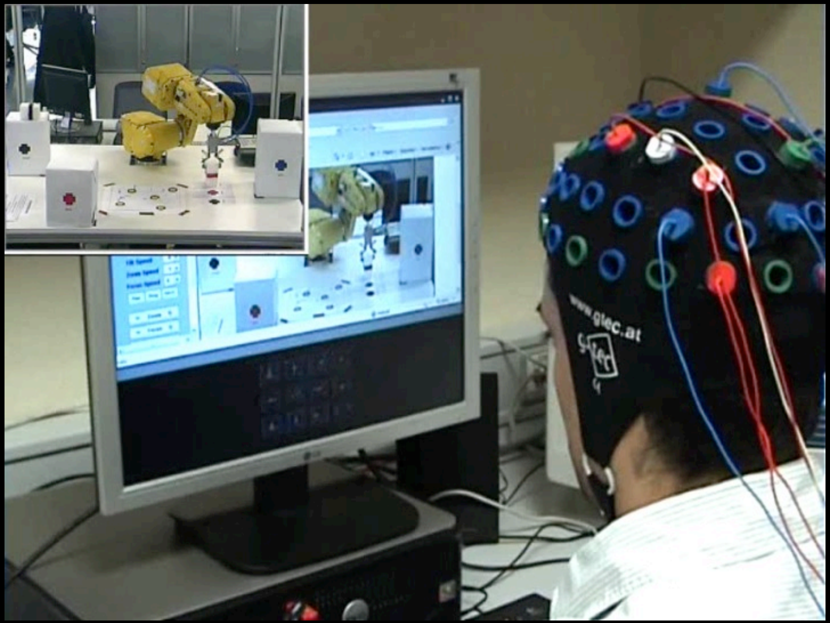
GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

Control of telerobotics systems using advanced interfaces for disabled people

- Ministry of Science and Innovation (Spain). Ref: DPI2008-06875-C03-03
- Dates: 01.01.2009-31.12.2011

Evoked BMIs





J.L. Sirvent, E. Iáñez, A. Úbeda, J.M. Azorín, "Visual evoked potential-based brain-machine interface applications to assist disabled people", Expert Systems with Applications, 39(9), 2012.

Communication system of basic needs based on EEG signals for people with severe brain damage and/or spinal cord injury

Supported by FUNDACIÓN MAPFRE (Convocatoria Ayudas a la Investigación 2013)

Brain2Motion

Development of a Multimodal Brain-Neural Interface to Control an Exoskeletal – Neuroprosthesis Hybrid Robotic System for the Upper Limb

- Ministry of Economy and Competitiveness (Spain). Ref: DPI2011-27022-C02-01
- Dates: 01.01.2012-31.12.2014

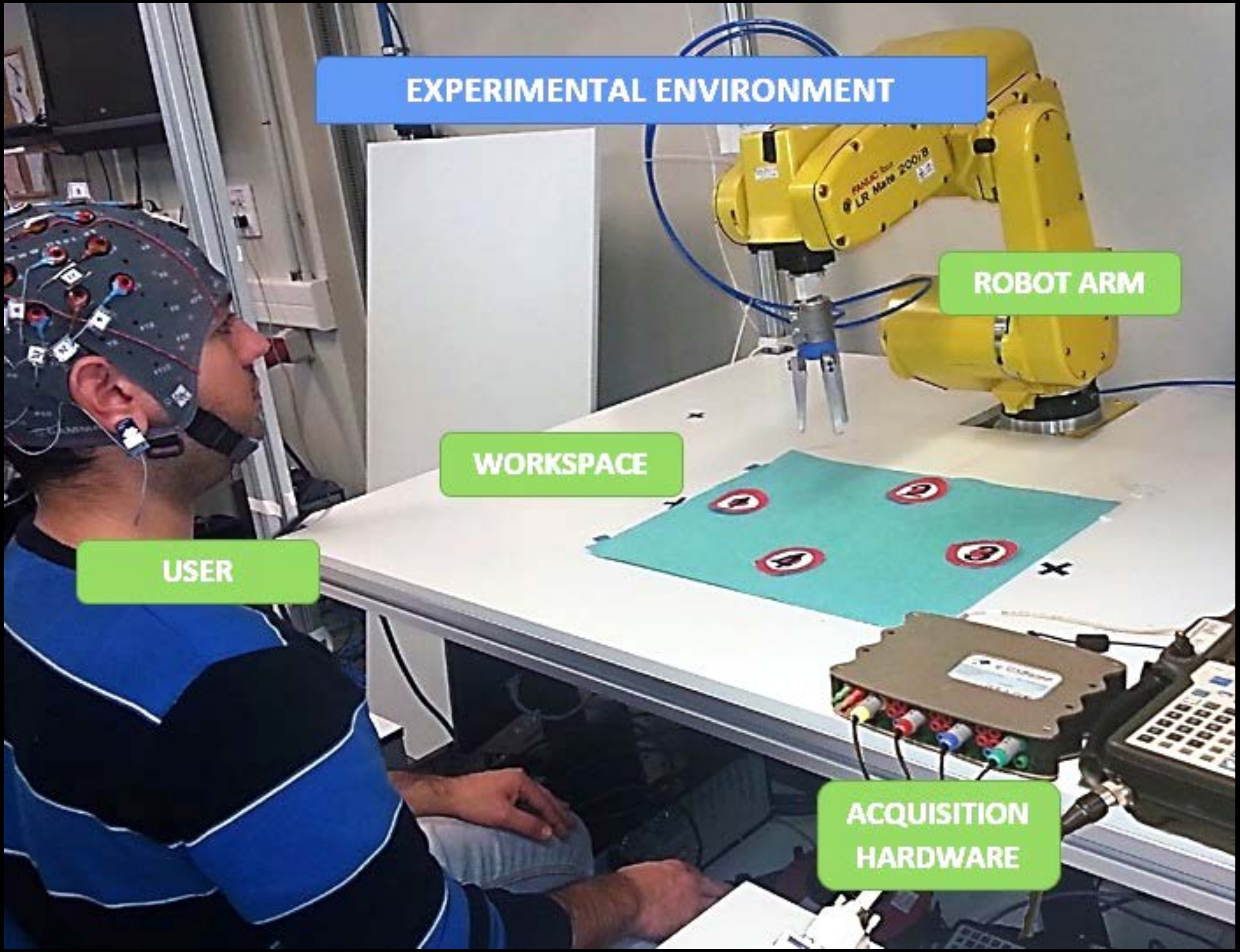
- Development of non-invasive spontaneous BMIs to control the robotic exoskeleton.
- Detecting the intention of movement.

GOBIERNO DE ESPAÑA
MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Spontaneous BMI based on 2 mental tasks

E. Hortal, A. Úbeda, E. Iáñez, J.M. Azorín, “Control of a 2 DoF Robot Using a Brain-Machine Interface”, Computer Methods and Programs in Biomedicine, Vol. 116(2), 2014.

Spontaneous BMI based on 4 mental tasks



E. Hortal, D. Planelles, A. Costa, E. Iáñez, A. Úbeda, J. M. Azorín, “Brain-Machine Interface based on four mental tasks for controlling a robot arm”, Neurocomputing, Vol. 151(1), 2015.

Control of a robotic exoskeleton

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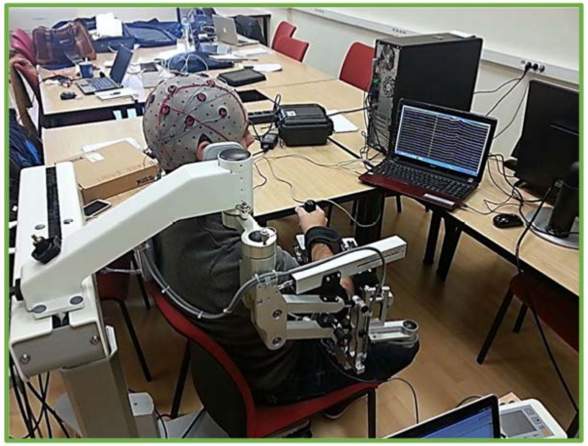
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

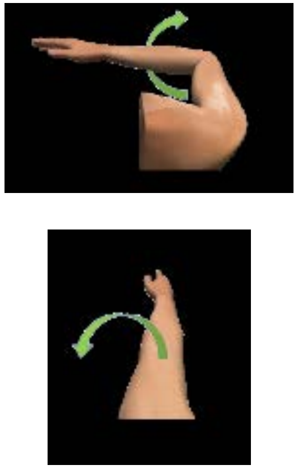
- Goals
  - Control an upper limb exoskeleton by motor imagery (mental tasks)/movement intention
  - Usability tests with patients during rehabilitation

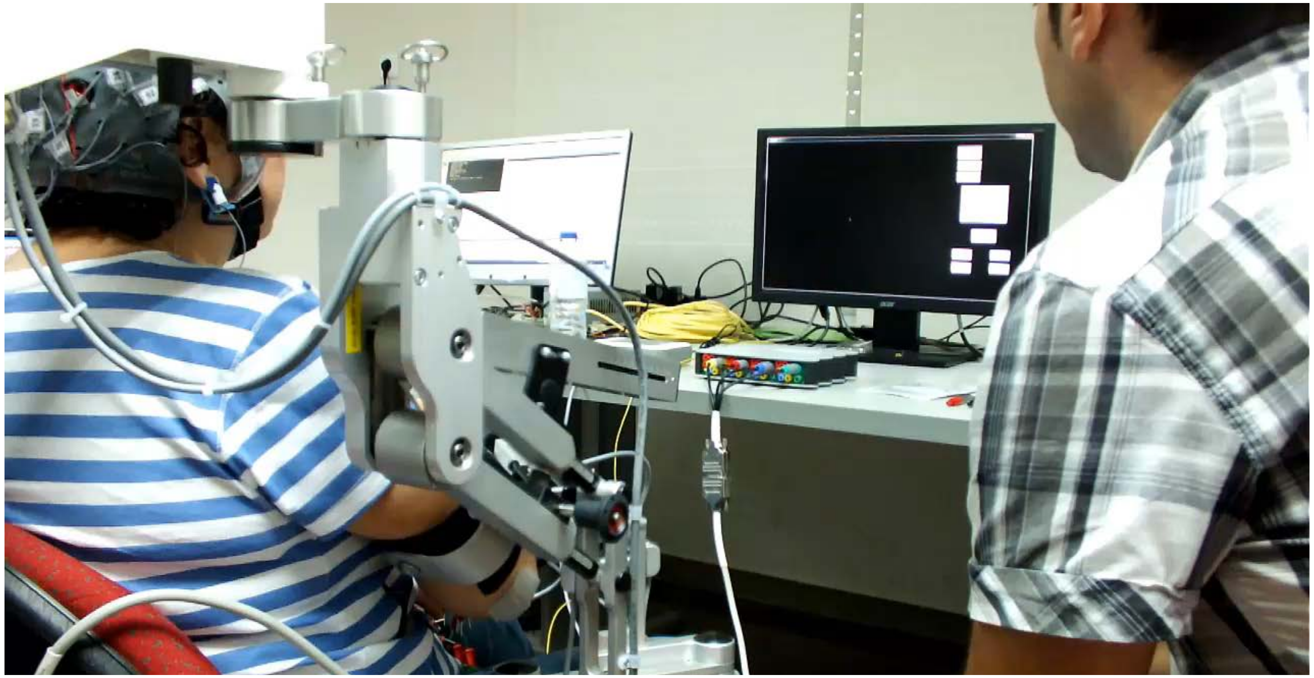
E. Hortal, D. Planelles, F. Resquin, J.M. Climent, J.M. Azorin, J.L. Pons, "Using a Brain-Machine Interface to Control a Hybrid Upper Limb Exoskeleton during Rehabilitation of Patients with Neurological Conditions", Journal of NeuroEngineering and Rehabilitation, 2015.

BMI based on motor imagery

- One mental task related to motor imagery:
  - Imagination of hand movement

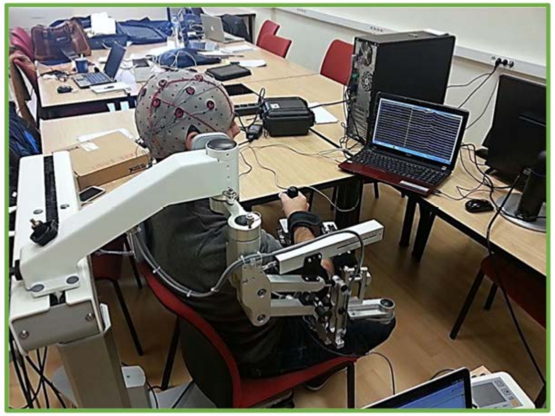


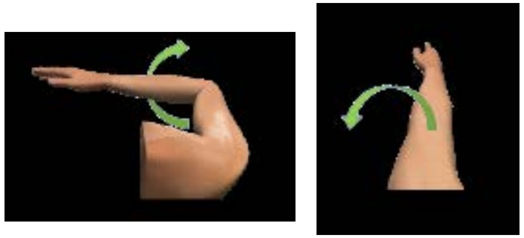




BMI based on movement intention of the upper limb

- Detection of the intention to perform a movement of the upper limb before it really happens

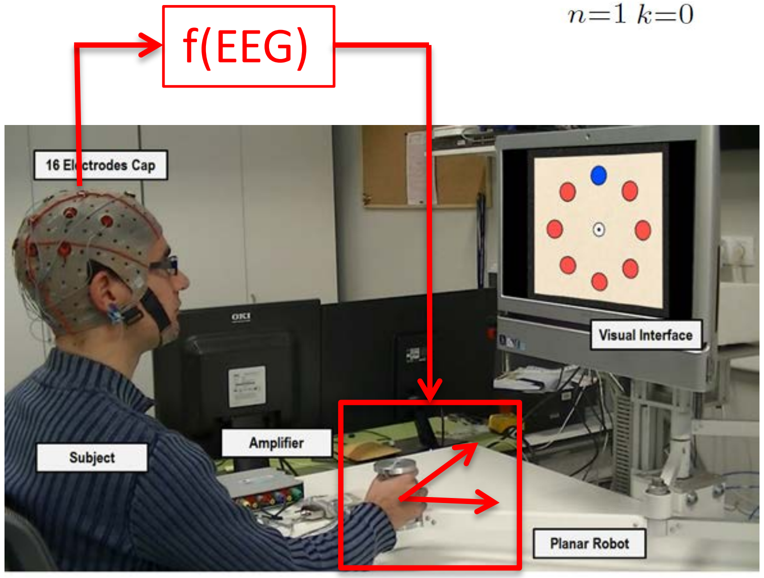




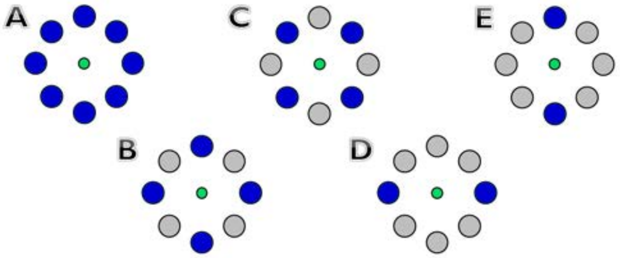
D. Planelles, E. Hortal, A. Costa, A. Úbeda, E. Iáñez, J.M. Azorín, "Evaluating classifiers to detect arm movement intention from EEG signals", Sensors, 14(10), 18172-18186, 2014.

Kinematics Decoding

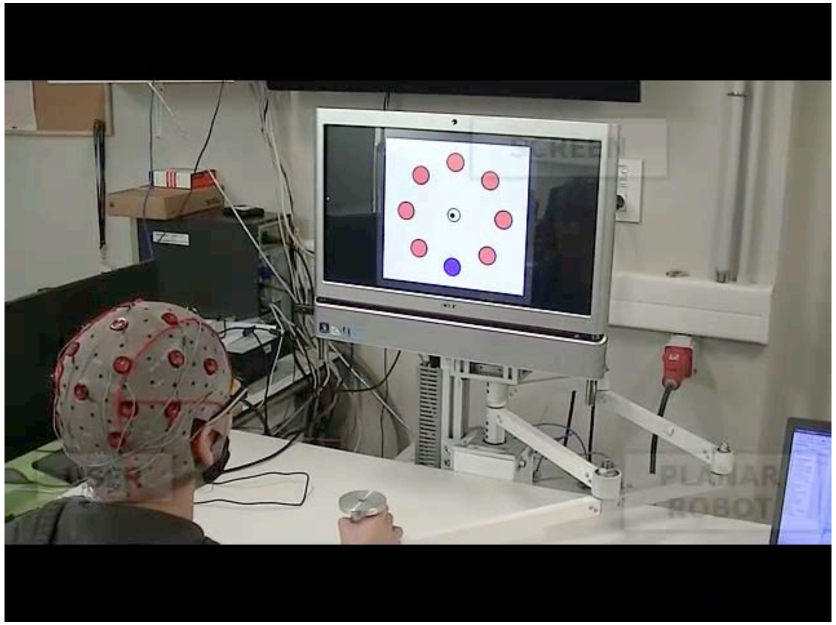
$$x\left[t\right] = a + \sum_{n=1}^{N}\sum_{k=0}^{L} b_{nk} S_n \left[t-k\right]$$

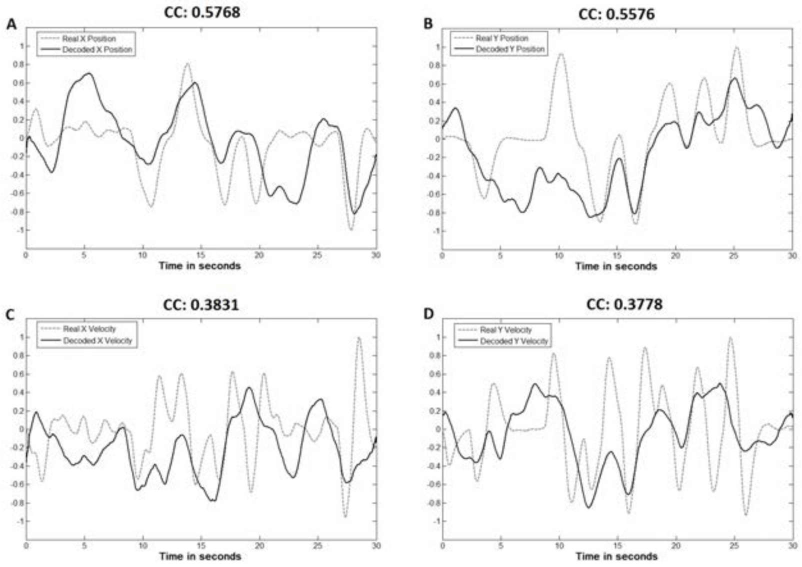


f(EEG)

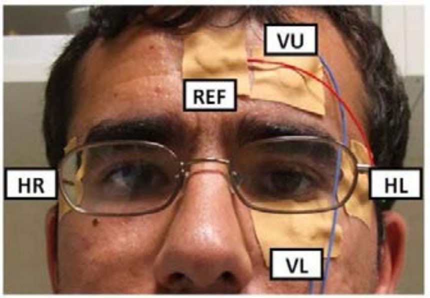


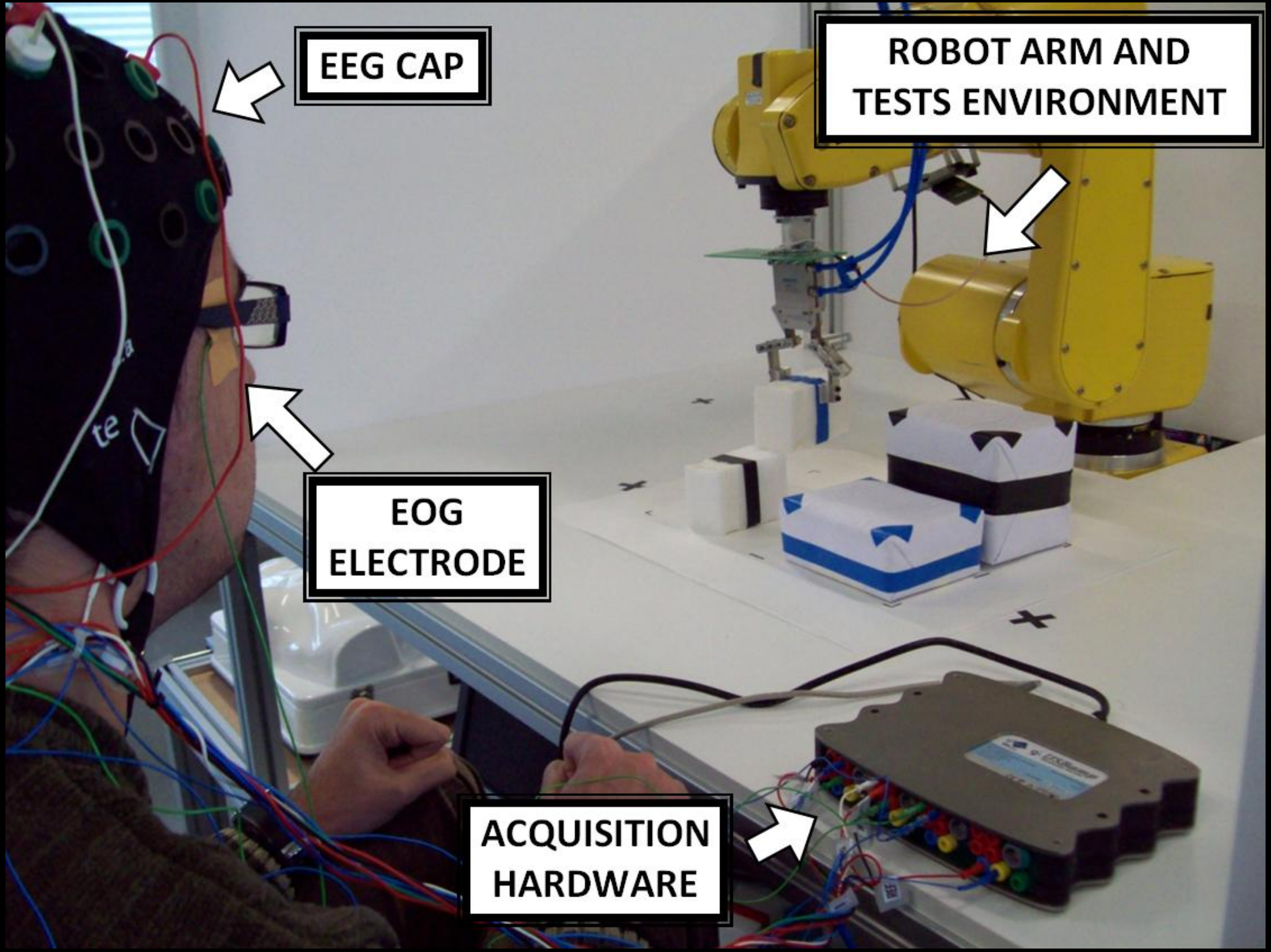
A. Ubeda, E. Hortal, E. Iáñez, C. Perez, J.M .Azorín, Assessing Movement Factors in Upper Limb Kinematics Decoding from EEG Signals, PLOS One, 2015.





Multimodal interface based on EEG and EOG signals





E. Hortal, E. Iáñez, A. Úbeda, C. Pérez-Vidal, J.M. Azorin , Combining a Brain–Machine Interface and an Electrooculography Interface to perform pick and place tasks with a robotic arm, Robotics and Autonomous Systems, 2015.

BioMot

Smart Wearable Robots with Bioinspired Sensory-Motor Skills

VII Programme Framework: FP7-ICT-2013-10-611695

Dates: 01.10.2013-30.09.2016

CSIC

Vrije Universiteit Brussel

Università degli Studi di Padova

ÖSSUR

Hospital Nacional de Parapléjicos Toledo

RIKEN

Universitas Miguel Hernández

TECHNAID

Cognitive mechanisms during walking

- **Detecting start/stop of gait cycle**
  - 45 experiments: 29 healthy, 16 i-SCI

Online results	Success Rate	FP/min	Precision
Healthy	58.8%	1.84	75.9%
i-SCI	55.1%	1.93	65.7%

E. Hortal et al., Detecting the intention of start and stop the gait through EEG signals, International Journal of Neural Systems (under review).

E. Hortal et al., Starting and finishing gait detection using a BMI for spinal cord injury rehabilitation, 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).

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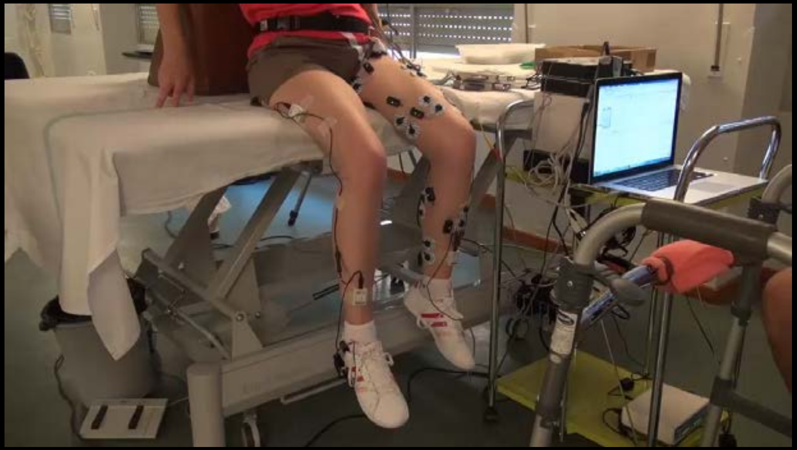

- **Decoding of lower limb kinematics**
  - 24 experiments: 14 healthy, 10 i-SCI
  - Higher correlation when more complex movements are performed -> more attention paid by user to perform these movements

Position	Sit			Stand	
Movement	**Knee**	**Pedalling**		**Bending Knee**	**Bending Ankle**
Joint	**Knee**	**Hip**	**Knee**	**Knee**	**Ankle**
Healthy users	0,27	0,27	0,43	0,24	0,30
i-SCI patients	0,36	0,38	0,48		
Total average	0,32	0,33	0,46		

E. Iáñez et al., Evaluating performance in the decoding of different lower limb activities from EEG signals, Frontiers in Neuroscience (under review).

A. Úbeda et al., Single Joint Movement Decoding from EEG in Healthy and Incomplete Spinal Cord Injured Subjects, 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) .

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- **Detection of obstacle appearance**
  - 22 experiments: 17 healthy, 5 i-SCI
  - Potential detected before the physical reaction of the user

	Offline	Online	
	Success Rate	Success Rate	FP/min
Healthy	79.3%	61.3%	11.5

R. Salazar et al., Analyzing EEG signals to detect unexpected obstacles during walking, Journal of NeuroEngineering and Rehabilitation, 2015.

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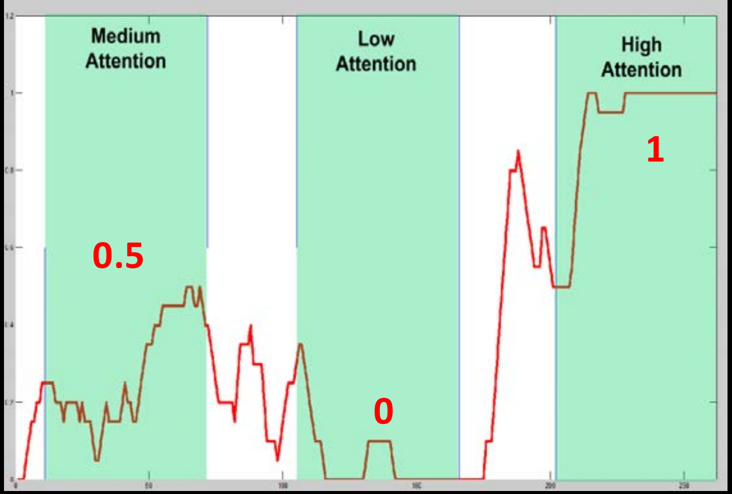
- **Environment detection**
  - 6 healthy users
  - 45% of success rate differentiation between 4 different environments (regular and soft floor, tilt and stairs)

Cognitive mechanisms during walking

Low Attention Level



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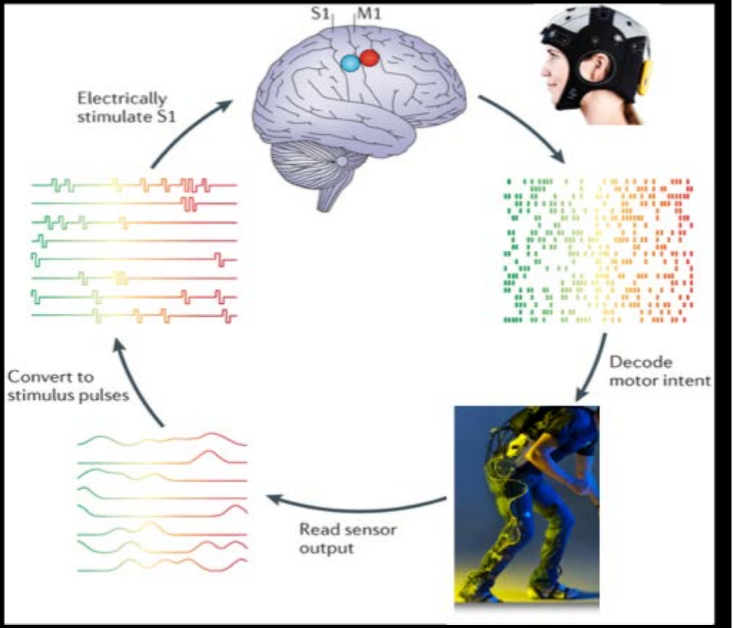
Environment detection

- 6 healthy users
- 45% of success rate differentiation between 4 different environments (regular and soft floor, tilt and stairs)

- **Attention level**
  - Classification of 3 different levels of attention on the gait

Associate

Decoding and stimulation of motor and sensory brain activity to support long term potentiation through Hebbian and paired associative stimulation during rehabilitation of gait



Ministry of Economy and Competitiveness (Spain). Ref: DPI2014-58431-C4-2-R
Dates: 01.01.2015 - 31.12.2018

- Definition and development of EEG-based decoders of gait initiation and other walking events.
- Definition of stimulation patterns and methods of sensory activity in the S1 cortex using tDCS.
- Integration of decoders and stimulation into a close-loop method for Long Term Potenciation (LTP).