Brain-Computer Interfaces and Neuroprostheses to Improve Rehabilitation in People with Disabilities

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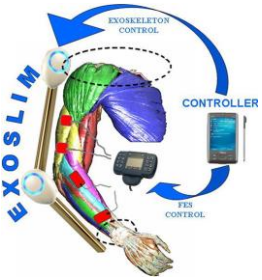
Functional Electrical Stimulation (FES) holds the premises to artificially control the musculoskeletal system aiming to improve quality of life in e.g. multiple sclerosis patients, or to provide targeted rehabilitation in e.g stroke patients. The devices integrating the programmable neurostimulators, sensors and specific FES-based control strategies are termed as neuroprostheses. The overall FES-based applications are part of a complex field of research and clinical rehabilitation procedures while they are intended to benefit users in multiple ways (e.g. improved walking in stroke, upper limb rehabilitation after stroke, FES as part of a rehabilitation methods in spinal cord injured (SCI) people, FES phrenic pacing system, Brain-Computer Interfaces(BCI)&FES to restore motor functions).

Direct communication pathways between the brain and external devices may be facilitated by means of so-called Brain-Computer Interfaces (BCI). While a user performs a mental task with distinct brain activities, that information can be identified within the electroencephalographic signals (EEG), enabling e.g. the control of a neuroprosthesis.



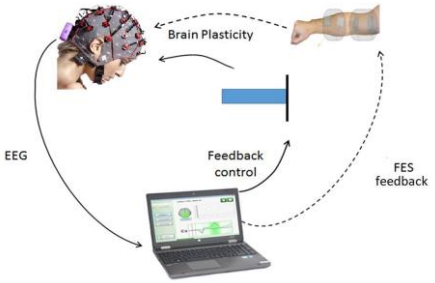
The hybrid FES&Exoskeleton system aiming to improve upper limb rehabilitation in stroke patients (EXOSLIM project).

The proposed presentation explores the last accomplishments within FES and robotic exoskeletons hybrid technologies used to support rehabilitation in stroke (CVA), SCI, cerebral palsy (CP) patients, the results and new proposed devices tested within IHRG (no.150/2012), EXOSLIM (no.180/2012)

and NOVAFES (no.267/2014), UEFISCDI awarded grants, as well as BCI applications, and the last result RecoveriX.

Assisting robotics allows patients to perform repeated movements in a well-controlled manner, while the FES-based activation of the muscles helps the brain to relearn daily movements. This phenomenon has been termed as neuroplasticity. Some of our findings with a novel hybrid FES exoskeleton EXOSLIM system sustain that hypothesis. The novelty of the proposed EXOSLIM device consists in a balanced control of the upper limb movements induced by the driven exoskeleton and the FES-based muscle activation. The system has been successfully tested clinically on two subjects which were satisfied with the design and performed exercises. Much more, the EXOSLIM system has been combined with BCI (motor imagery tasks) and it proved the feasibility to control the EXOSLIM system via BCI.

Another rehabilitative system IHRG targeted the hand and its fine control. The proposed hand rehabilitative IHRG system supports a balanced control between FES and an actuated glove while taking into account the patient's intention to perform hand/fingers opening movements. A clinical randomized controlled study was conducted to test the IHRG system and the patients in the IHRG group showed a slight increase of average motor gain than the control group assessed with Fugl-Meyer Assessment (FMA) and Box and Blocks test (BBT) – only two weeks' therapy.



The schematic view of a BCI&FES system

Since 2012, one of our main research interest, in collaboration with a company producing BCIs (g.tec medical engineering GmbH, Austria), was to combine the BCI and FES technologies in order to achieve improved results of the rehabilitation process for upper limb in stroke patients. It led to the RecoveriX product which is currently available on market.

Finally, further ideas for cooperation in the frame of national and international grants are to be discussed.