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Adaptive Control Strategies in Hybrid Upper Limb Exoskeletons for Functional Rehabilitation after Stroke

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Introduction

Stroke is currently an important social and health care problem due to the high number of new reported cases on every year. More than 70% of stroke patients have motor impairment and less of 40% of this population are able to fend for themselves [1]. Rehabilitation therapies are in most cases insufficient to retrieve functional capabilities to carry out daily activities [2].

In order to facilitate neural plasticity and promote functional improvement at motor level, the use of functional electrical stimulation combined with robotic exoskeleton (resulting in a hybrid approach) have been proposed for functional rehabilitation [3].

Rehabilitation outcomes are maximized when hybrid system is applied coincidentally with the patient's own voluntary intention to move [4]. Hence, electrical signal at cortical (EEG) and muscular (EMG) level are used to trigger the task execution and mimic the biological motor control existing in healthy subjects.

Concept

The concept developed in this work relies on a modular rehabilitation system based on a cooperative assistance strategy able to adapt the level support to the user's residual capabilities.

The system is composed of physiological sensors (EEG and EMG) allowing the detection of the user intention to execute a task. Actuators (FES+Exo) that assist the movement execution in a cooperative manner according to the motor residual capabilities of the user (assisted-as-needed paradigm). Further, the system provide sensory feedback with the aim to facilitate neural ascending pathway and promote motor relearning.

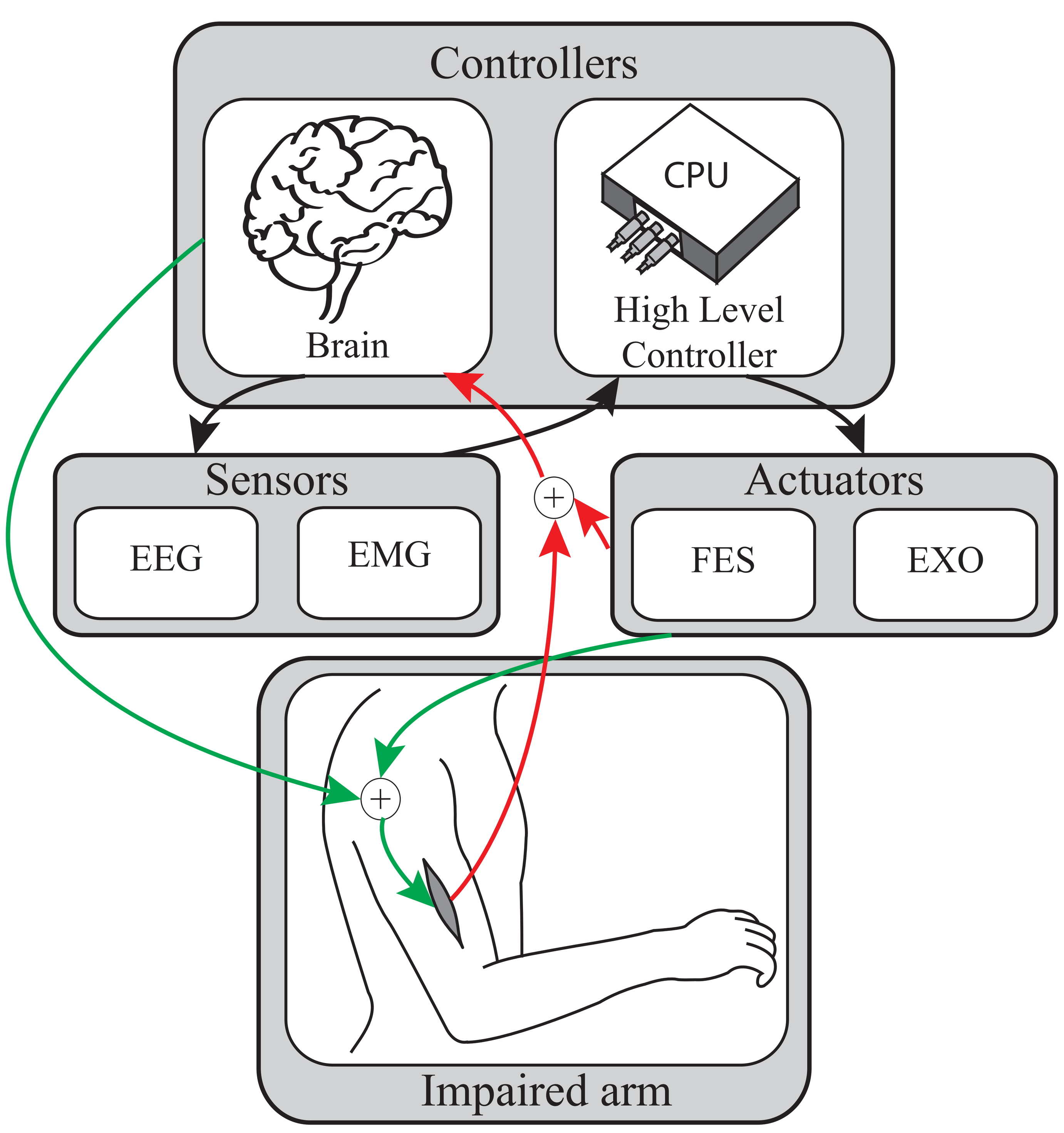

Figure 1. Rehabilitation concept implemented in this work.

Hybrid system

Cortical and peripheral information (EEG+EMG) are combined by mean of a multimodal interface with the aim to generate voluntary commands that trigger the assistance of the hybrid system.

An adaptive controller is implemented under the rehabilitation paradigm "assisted-as-needed". Further, this controller is able to compensate the time-varying response of muscle-skeletal system and the effects of muscle fatigue due to FES.

The system includes a visual feedback module to promote additional perception and cognition pathways, and stimulate motor relearning. A simple user interface was designed to enhance system usability.

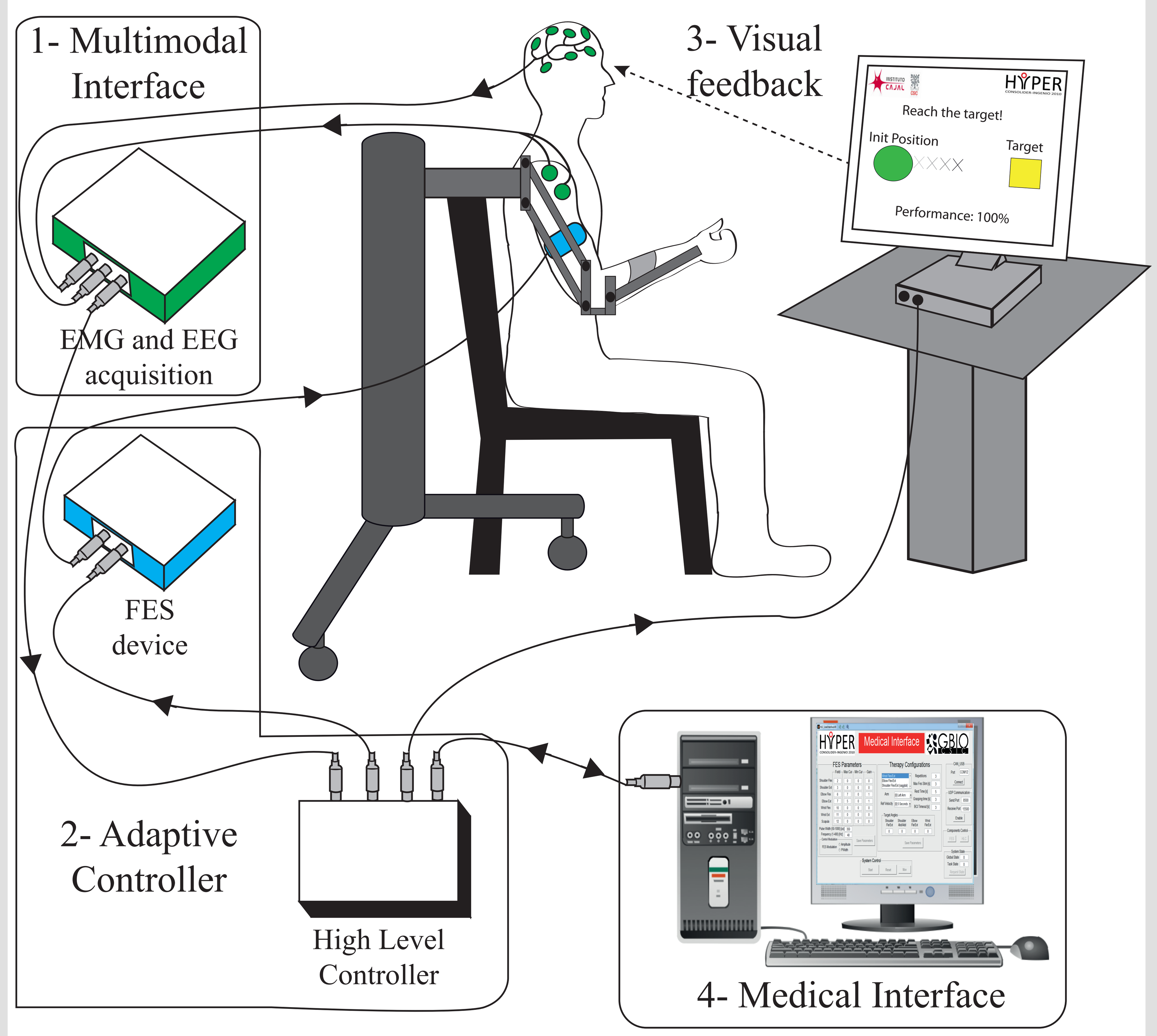

Figure 2. General scheme of the system.

Conclusions

The first hybrid system for upper limb rehabilitation triggered by a multimodal interface is presented. The system presents a more inclusive approach and promotes motor relearning by mean of motor descending pathway facilitation.

Bio-inspired control strategies facilitate system adaptation in accordance to the user functional capabilities.

References

[1] P. Langhorne, J. Bernhardt, and G. Kwakkel, "Stroke rehabilitation," Lancet, vol. 377, no. 9778, pp. 1693–1702, 2011.
[2] N. Takeuchi and S. I. Izumi, "Rehabilitation with poststroke motor recovery: A review with a focus on neural plasticity," Stroke Res. Treat., vol. 2013, 2013.
[3] J. W. Krakauer, "Motor learning: its relevance to stroke recovery and neurorehabilitation," Curr. Opin. Neurol., vol. 19, no. 1, pp. 84–90, 2006.
[4] Y. Hara, "Rehabilitation with Functional Electrical Stimulation in Stroke Patients," Int. J. Phys. Med. Rehabil., vol. 01, no. 06, pp. 1–6, 2013.

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