Objectives
The Integrated Project “Assistive and Health” since end 2016 targets to (1) provide advanced healthcare methodologies and technological tools to support health professionals to quantify and measure objectively the movement, the clinical status and/or the rehabilitation progress of patients suffering from neurological disorders (e.g., chronic or sudden brain/spinal cord injuries), towards developing effective and case-specific rehabilitation programmes; (2) investigate large-scale brain plasticity of the sensorimotor network, at both inter- and intra-hemispheric levels with the help of combined neuroimaging methods and computer modeling approaches; (3) design and provide surgical gestures guidance, learning, training and evaluation with the help of advanced medical devices.

Contributions
During the last years, several projects have been carried out in collaboration mainly with the CHU of Nîmes and Montpellier. One PhD work defended last 2017 funded by the IP proposed a new animal model of direct spinal stimulation on bladder and bowel functions facilitated by an innovative powerful stimulation device enabling real time modulation of stimulation parameters. This study showed, for the first time, that epispi- nal stimulation causes significant detrusor and rectal responses (Fig. 1) in pigs and allows considering further studies with the objective of treating urinary and rectal disorders in spinal cord injury patients.

Fig. 1. Bladder and rectum pressure profiles recorded while stimulating with the needle electrode. During this stimulation session, stool evacuation was induced causing the expulsion of the rectal balloon — this expulsion is manifesting itself by a decrease in the recorded rectal pressure before the end of the stimulation.

Thereafter, one can cite a second current granted PhD work aiming to evaluate subtle subcortical changes on resting state level with new tools based on functional magnetic resonance imaging (fMRI) and electroence-
phalography (EEG) techniques before and subsequent to wide-awake surgery for brain diffuse low-grade glioma. It is expected that the complementarity of these modalities (spatial resolution with fMRI vs. temporal with EEG) makes it possible to identify and quantify the phenomena of plasticity in the whole brain over time. Another PhD work supported recently by the IP aims to propose new approaches to functional electrical stimulation for lower limb movement assistance using a theoretical framework and an embedded network of generic sensors – actuators (Fig. 2) in Parkinson’s disease, hemiplegia or paraplegia. A preliminary study showed a positive global effect on gait and freezing of gait episodes occurrence (decrease of 12%) in subjects with Parkinson’s disease by a somatosensory cueing based on sensitive electrical stimulation.

One collaborative project (LIRMM-EuroMov) was also funded within the IP through an equipment combining near-infrared spectroscopy (NIRS) and EEG neuroimaging techniques to guide multi-electrode transcranial electrical stimulation to modulate cortical excitability/activation at the cortical ‘motor hotspot’ in healthy humans. A proof-of-concept study has provided evidence to confirm that functional NIRS neuroimaging can be used to provide a hemodynamic correlate of the anodal high-density transcranial direct current stimulation electric field in humans. This finding can be used to provide information about the brain-tissue effects of the electrical stimulation when measured in a resting-state during and/or after interventions in humans. The IP funded also a post doc (L. Van Dokkum) to work on the dynamic perspective of the brain functions from the functional integration of distributed networks. By confronting anatomical disconnectivity with functional connectivity of resting-state networks and task performance on a semantic language task, this research program was able to highlight continuous plasticity with shifting activity to the edges of the tumor/cavitas.

It is important to note that the IP supports and promotes scientific meetings, for instance in September 2017 to increase the interaction between neurophysiologists, engineers, mathematicians and clinicians: the 7th joint workshop on new technologies for computer/robot-assisted surgery and the annual scientific meeting of the “Institut Fédératif de Recherche sur le Handicap” on new technologies for restoring movement and provide assistive.

Regarding training related to research activities, a Research Engineer has been funded and recruited for 12 months (12/2017 to 11/2018) to support and take in charge the equipment/platforms of the medical robotics group of LIRMM located since October 2017 at the new Montpellier-Nîmes Medical School which integrates an innovative "Learning and Simulation Medical Training and Research Center" and an “Experimental Surgery Lab.”.

The vocation of this training center, especially through the medical and surgical robotics equipment and platforms of LIRMM, is to train the doctors and the surgeons for the practice of the medical robotics gesture and for the new computer and robot-assisted medical and surgical technologies.

References


Fig. 2. The subject is equipped with an inertial measurement unit (a) and a programmable stimulator (b) wirelessly connected through a PC.