HExEC: Hand Exoskeleton Electromyographic Control

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***Abstract*— In the domain of space exploration, as in other dangerous environments, strength, endurance, and dexterity are key issues to insure the health of the involved people. Hands are by their very nature one of our primary interfaces to influence and interact with the external world. For these reasons, at the center for Space Humanoid Robotics (SHR) we are studying ways to help cosmonauts overcome the stiffness of the gloves used for extra vehicular activity (EVA) by mean of a lightweight active hand exoskeleton. In this paper we position our work on electromyography (EMG) of the upper limbs as a tool to control a device like the hand exoskeleton. In fact, we are studying EMG signals to extrapolate information about the muscular status of the hands and concurrently we are using the information to support cosmonauts movement.**

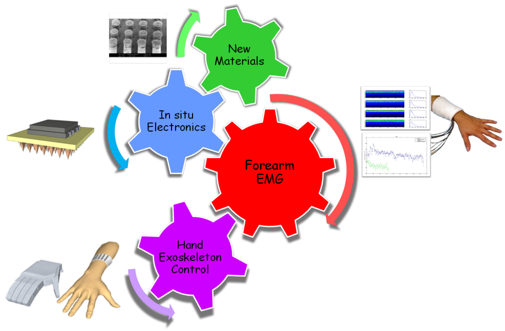

Fig. 1. HExEC Rationalel

I. HExEC

Extra Vehicular Activities (*EVAs*) are operations carried out by cosmonauts in the dangerous environment outside spacecrafts. Due to the need to protect the cosmonauts from various hazards such as the vacuum, extreme temperatures, micrometeoroids, and unfiltered high energy cosmic radiations, spacesuits are composed of a complex and highly technological multilayer structure [1]. Such a design imposes limitations to the mobility of the cosmonauts, particularly to the hands, which on the contrary, would need to work in agile and light environment to maintain the dexterity, endurance, and strength. At the center for Space Humanoid Robotics we are developing exoskeletons helping cosmonauts overcome the stiffness of the EVA glove [3]. Such a device could also be used for terrestrial applications, specifically in extreme environments, such as scuba diving or war operations, and in the domains of elderly care and upper limb rehabilitation.

Several examples of exoskeletons have already been presented in literature [4], unfortunately they are all characterized by bulky and heavy devices. In most of the scenarios bulkiness, weight, and power consumption are not an issue given the use of such devices in teleoperations, virtual reality, or in the best of cases, hand rehabilitation but in space, all of these issues are central and demand for the development of new lightweight and precise sensors and actuators. Furthermore, the usual control scheme is external to the device or constituted by tracking based on pressure and position sensors. While this approach is, in theory, perfectly sound, concerns about security in space applications demands the use of multiple control schemes and redundancy which cannot be achieved solely by information on pressure and position.

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Electromyography (*EMG*) is the technique which evaluates and record the electrical activity produced by skeletal muscles. We claim that, analyzing the dynamics of EMG signals of the forearm it is possible to recognize the muscular activation of each single finger thus, we are evaluating this technique as a way to overcome drawbacks of other technologies. Nevertheless, to achieve such a breakthrough, several technological improvements need to be done to the state of the art on which we are currently focusing:

1) as a first step we are studing materials and designs to build new EMG electrodes to reduce and stabilize the electrode–skin interface impedance thus improving the signal to noise ratio (*SNR*);
2) we are developing in-situ electronics to preamplificate, condition, and digitalize the EMG signal leading to even better SNR;
3) we are studying dense arrays of EMG sensors for the classification of hand and finger movements.

In figure 1 we exemplify these steps: new materials are studied to build new electrodes with in–situ electronics; these EMG electrodes are used to record the electrical activity of the forearm thus helping the control of the hand exoskeleton.

References

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