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DIGITAL CONTROLLER FOR ARTIFICIAL LIMBS FED BY NEUROMUSCULAR INTERFACES VIA OSSEOINTEGRATION

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Although the development of bioelectrically controlled upper limb prosthesis started in the 1970's, the majority of amputees do not use this technology due to its poor functionality, reliability and comfort.
This study is based on the previous work conducted by Ortiz-Catalan, Håkansson, and Brånemark, who developed a permanent bidirectional interface into the human body, namely the Osseointegrated Human-Machine Gateway (OHMG)[1, 2] (Fig.1).

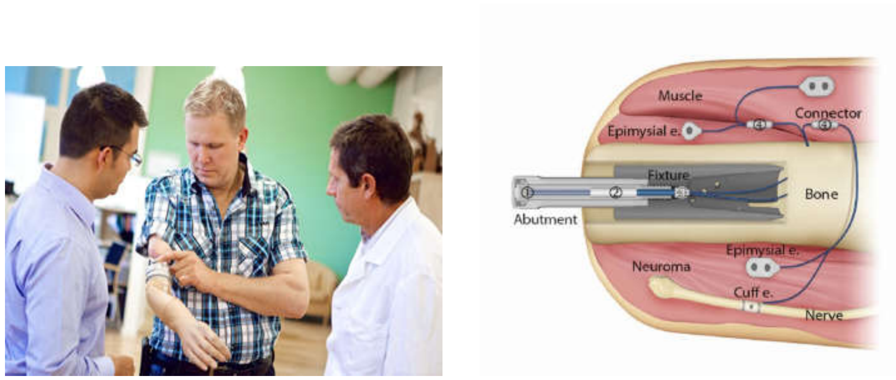

Figure 1. Osseointegrated Human-Machine Gateway (OHMG).

The aim of this study was to develop an Artificial Limb Controller (ALC) that decodes motor volition and provides sensory feedback using the OHMG (Fig. 2).
The system is composed by 3 stacked modules (Fig. 3):

- Neurostimulator (NS)
- Mixed signals processing unit (MSPU)
- Prosthetic control unit (PCU)

The MSPU is responsible for managing all the modules, bioelectric and artificial signal processing, and motor volition decoding. In the MSPU bioelectric signals are digitalized at 24 bits with a variable sampling rate. Band-pass and power line notch filters are implemented via firmware. Pattern recognition and direct control algorithms are implemented and were evaluated in real-time. The data from the force sensors in the artificial limb is then used to mediate the stimulation pulses that are generated by the NS to elicit the perception of touch. In its simplest stimulation mode, amplitude and pulse-width are constant while the frequency varies proportionally with the grasping force.
A communication dongle can be plugged into the system providing wireless communication with a PC for fitting, monitoring and data management. The system includes a SD card to continuously keep track of all relevant processes in order to better understand prosthetic use and the potential sources of errors. Inertial sensors are also included in the system not only to complement information on prosthetic use, but also to potentially improve the controllability of the system by incorporating such information in the motor volition decoding task. This system has passed bench tests and is currently under clinical implementation.

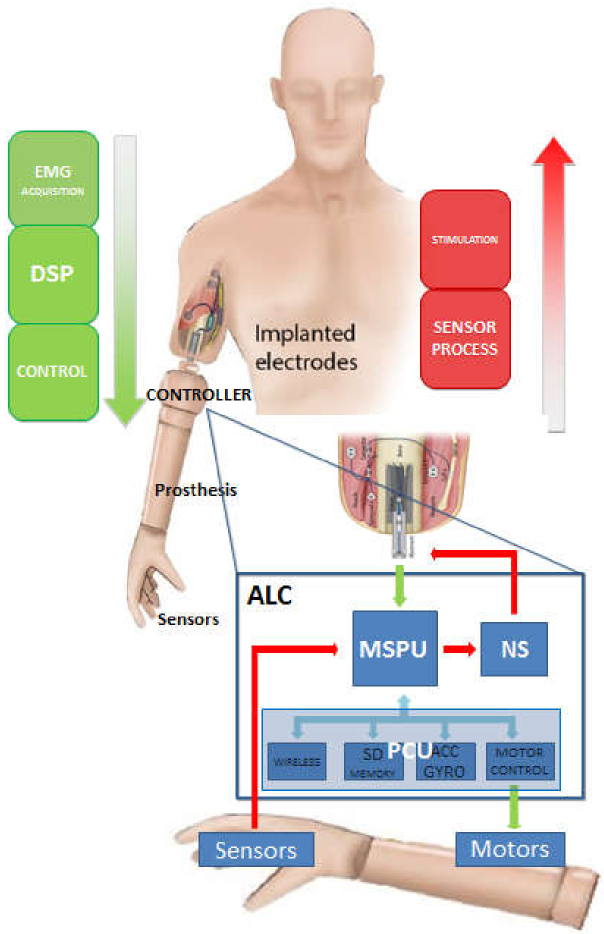

Figure 2. System overview.

Figure 3. PCBs.

References:

[1] R. Brånemark, Ö. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, "A novel osseointegrated, percutaneous prosthetic system for treatment of patients with transfemoral amputation: A prospective study of 51 patients," *Bone Jt. J*, vol. 96-B, no. 1, pp. 106–113, 2014.

[2] M. Ortiz-Catalan, B. Hakansson, and R. Branemark, "An osseointegrated human-machine gateway for long-term sensory feedback and motor control of artificial limbs," *Sci. Transl. Med.*, vol. 6, no. 257, pp. 257re6–257re6, Oct. 2014.