ELECTRICAL, ELECTRONICS AND COMMUNICATIONS ENGINEERING

DET - Embedded systems for intelligent neural interfaces for bidirectional connection with exoprostheses and exoskeletons

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Context of the research activity	The main goal of the NerveRepack project (EU Horizon project "Intelligent neural system for bidirectional connection with exoprostheses and exoskeletons — NerveRepack", project no. 101112347) is to develop a new generation of bidirectional implantable electrodes connecting the human nervous system with external mechatronic aid devices such as exoskeletons and exoprostheses, thus helping people with arm amputations or leg paralysis regain their motor and sensorial functions. Electrodes will be the primary bidirectional interface to the nerves, connected to an the implantable wireless module. To enable wireless power transfer and data communication from/to the mechatronic structures of exoprosthesis or exoskeletons, an embedded system will be designed, fabricated, and tested. This system will then be integrated into the mechatronic structures. Due to the presence of bidirectional implantable electrodes a close loop between the user's brain and the device's control system will be created, with the AI module being used to learn and interpret the user's synaptic signals.
Objectives	The embedded systems considered in the NerveRepack project, specifically customized and integrated in the exoprosthesis/exoskeletons, will be designed around a common electronic platform featuring: 1) Resonant inductive (near-field) wireless power transfer system, optimized for reliably and safely powering the implanted device. 2) Wireless short-range low-power connectivity for controlling and transmitting data for neural recording/stimulation. 3) Optimized, energy-efficient, power electronics for driving the electromechanical actuators of the mechatronic structures, including supercapacitors to boost the driving performance. 4) Hybrid energy storage system, including batteries and supercapacitors, related power management system, and an external recharging station for ensuring a full-operation time of about 8 hours between two consecutive recharging stages.

	5) A control and data processing sub-system for executing AI modules in real-time for an effective bidirectional high-level information flow between the implanted bioelectrical neural interfaces and mechatronic structure of the exoprosthesis/exoskeletons. 6) Data acquisition modules for tactile feedback and pressure sensors.

Skills and competencies for the development of the activity	Design of embedded systems; Design of biomedical active devices and systems; Power Management Systems (PMSs) and Wireless Power Transfer (WPT) systems design and development; PCB development; Design and development of analog front-end and data acquisition systems for resistive/capacitive transducers; Firmware development; Test and validation of electronic systems.