



PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 38th cycle

Research Area n. 4 - Telecommunications

**PNRR_351_DOTT_RICERCA Research Field: DESIGN AND PROTOTYPING OF A
PERIPHERAL NEURAL INTERFACE FOR THE SENSING, TRANSMISSION, AND
PROCESSING OF ENG SIGNALS**

Monthly net income of PhDscholarship (max 36 months)

€ 1250.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

**Motivation and objectives of the research
in this field**

Peripheral nerve (PN) disorders affect over one million people worldwide every year. Although clinical and preclinical research has achieved remarkable progresses in biological and cellular strategies for reconstruction of PN injuries, a satisfactory functional recovery has not been guaranteed yet and, therefore, better approaches must be developed.

PN signals stimulate muscles, but if these signals could be extracted (even if weak) and processed, one can get a near-natural and intuitive control of prosthetic limbs. The main objective of this project consists in the development of a fully implantable and highly compact neural interface to sense PN activity, defined as electroneurogram (ENG), through the use of extra neural prostheses Cuff Electrodes, on disabled patients. The device is intended for use in the therapeutic and rehabilitative processes that support the re-establishment of the physiological motor act.

The main requirements for the device are wireless bidirectional data communication and configurability of recording and stimulating settings.

Main goals of the research are:

1) Design of an innovative wrapping cuff electrode for



	<p>sensing weak PN signals. Key aspects are flexible mechanical structure and biocompatibility.</p> <p>2) Development of deep learning-based classification algorithms to recover the information encoded in PN signals and translate them into actuation signals for neuroprostheses.</p> <p>3) Design of a neural interface system to record and reliably relay neural signals. This requires an electronic circuit for signal conditioning.</p> <p>4) Evaluate the efficiency of alternative schemes for extra-body relaying PN signals (e.g., digital vs. hybrid).</p> <p>5) Evaluate suitable technologies for transcutaneous information and power transfer, i.e. wireless vs. wired.</p>
Methods and techniques that will be developed and used to carry out the research	<ul style="list-style-type: none"> -design of a neural interface (electronic circuit, cuff electrode) with configurable recording/stimulation settings -bidirectional communication for intra/extra-body relaying of neural signals -machine learning classification -wireless transcutaneous power and data transfer
Educational objectives	<p>1) acquire an expertise in technologies for implantable devices 2) perform experimental activity 3) disseminate research results (oral presentations/written publications 4) ability to identify research problems 5) develop skills for life-long learning and professional development</p>
Job opportunities	<p>Public and private institutions, universities, research centers in the fields of: 1) eHealth science 2) communication-enabled technologies interfacing with the nervous system 3) medical devices that interface with neural pathways</p>
Composition of the research group	<p>0 Full Professors 3 Associated Professors 1 Assistant Professors 5 PhD Students</p>
Name of the research directors	Maurizio Magarini

Contacts	
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web-page: <https://magarini.faculty.polimi.it/>

Additional support - Financial aid per PhD student per year (gross amount)

Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad

Amount monthly	625.0 €
By number of months	6

National Operational Program for Research and Innovation

Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	Imperial College, London
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

ATTINENZA ALLA TEMATICA PRESCELTA

Ambito Salute. 1.4 Tecnologie per la salute. Articolazione 7. Dispositivi medicali, organi artificiali e tecnologie neuromorfiche per la medicina bionica e rigenerativa

L'attinenza riguarda lo sviluppo di dispositivi impiantabili biocompatibili per la misura, la trasmissione, e la classificazione di segnali che si propagano nel sistema nervoso periferico per il controllo di organi artificiali e il supporto del ripristino dell'attività motoria. Lo sviluppo di interfacce neurali impiantabili è una grande sfida che è attualmente perseguita da diversi gruppi di ricerca a livello mondiale. L'entità della domanda di mercato per tali tecnologie sta attirando enormi investimenti. L'obiettivo prioritario riguarda lo sviluppo di dispositivi impiantabili biocompatibili alimentati dall'esterno. La proposta ha come elementi di maggior innovatività l'applicazione di tecniche deep learning per la classificazione dei segnali neuronali e lo studio di soluzioni per trasferimento simultaneo di informazione e potenza wireless.

ENTE, UNIVERSITÀ, AZIENDA, CENTRO DI RICERCA PRESSO CUI SI SVOLGERÀ IL PERIODO DI STUDIO E RICERCA ALL'ESTERO

È previsto un periodo della durata di 6 mesi presso il laboratorio "Next Generation Neural Interfaces Lab" dell'Imperial College di Londra diretto dal Prof. Timothy Constandinou

Il gruppo di ricerca del Prof. Timothy Constandinou ha già progettato e implementato un



dispositivo di interfaccia neurale completamente impiantabile, chiamato SenseBack, che rappresenta lo stato dell'arte della tecnologia nel settore. Gli obiettivi principali dell'attività durante la visita riguarderanno:

- comprensione delle caratteristiche del sistema SenseBack, con particolare attenzione agli aspetti legati all'alimentazione e alla biocompatibilità;
- valutazione di soluzioni hardware per l'alimentazione del dispositivo impiantabile;
- definizione di un setup sperimentale con l'obiettivo di generare potenziali evocati standardizzati, ridurre al minimo gli artefatti dell'operatore ed estrarre il segnale ENG con l'analisi dei dati.

EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student

5.095,96 Euro per student

TEACHING ASSISTANTSHIP: (availability of funding in recognition of supporting teaching activities by the PhD student)

There are various forms of financial aid for activities of support to the teaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.

COMPUTER AVAILABILITY: individual use

DESK AVAILABILITY: individual use