POLITECNICO DI MILANO

# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

## THEMATIC Research Field: A SECOND SKIN HYBRID EXOSUIT FOR REHABILITATION ACROSS THE CONTINUUM OF CARE

| Monthly net income of PhDscholarship (max 36 months) |
| --- |
| **1500.0**<br>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** | Task-oriented, high-intensity training with active patient participation promotes cortical reorganizations and motor recovery after stroke (French et al, Cochrane, 2016). Research highlights the importance of combining volitional effort, effective movement execution, and augmented proprioception for motor relearning in neurological patients. However, existing rehabilitation technologies often lack these critical elements and face barriers such as bulkiness, high cost, complexity, and limited usability. This study aims to develop a user-centered rehabilitative platform guided by usability and technological democratization principles. The proposed solution is a hybrid second-skin suit designed for rehabilitation across the continuum of care, integrating: i) a human-machine interaction module to detect and incorporate the user's volitional intention into the control loop; ii) a second-skin exosuit providing variable assistance based on the assistance-as-needed model; iii) a Functional Electrical Stimulation (FES) module with textile electrodes to enhance proprioception and neuroplasticity, synchronized with the user's intention (Ambrosini et al, NNR, 2021); iv) a user interface for remote therapy and progress monitoring. By combining these components, the system aims to deliver effective and engaging treatment, while empowering healthcare providers to monitor and optimize patient care. |
| **Methods and techniques that will be** | The research integrates methodologies from mechanical |

| | |
|---|---|
| **developed and used to carry out the research** | The research integrates methodologies from mechanical design, mechatronics, and bioengineering. It combines mechanical engineering skills, such as exosuit and sensor network design, with bioengineering expertise in Functional Electrical Stimulation, patient monitoring, and device validation. The project is per se interdisciplinary, aiming to combine robot-assisted therapy and FES, known as hybrid robotic systems, to overcome the limitations of each approach alone, such as robotic therapy's repetitiveness and FES-induced muscle fatigue, promoting upper limb recovery in post-stroke patients (Ambrosini et al., 2019, IEEE Trans Biomed Eng). While hybrid systems with FES integrated into rigid exoskeletons exist, no exosuits targeting upper limbs currently integrate FES. |
| **Educational objectives** | PhD graduate will be able to have an interdisciplinary knowledge of technologies and processes related to new paradigms in human assistance and empowerment. The proposal is part of the university's multidisciplinary initiatives and contributes in particular to SDG3 (Good Health). The project intends to integrate the skills for mechanical support with proprioceptive training to support rehabilitation and daily life activities execution. |
| **Job opportunities** | Skills and competences in the field are extremely interesting for all the companies, rehabilitation centres, and regulatory institutions involved in the rehabilitation and assistance of frail people. Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary, compared Master of Science holders in the same field. |
| **Composition of the research group** | 1 Full Professors<br>2 Associated Professors<br>0 Assistant Professors<br>3 PhD Students |
| **Name of the research directors** | Prof. F. Braghin, Prof. M. Gandolla |

| **Contacts** |
|---|
| For questions about scholarship/support Francesco.braghin@polimi.it, marta.gandolla@polimi.it, phd-dmec@polimi.it |

| Additional support - Financial aid per PhD student per year (gross amount) | |
|---|---|
| **Housing - Foreign Students** | -- |
| **Housing - Out-of-town residents** | -- |

| Scholarship Increase for a period abroad | |
|---|---|
| **Amount monthly** | 750.0 € |
| **By number of months** | 6 |

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

Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of € 6.114,50. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 750 euro/month - net amount). Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. 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.