



# PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

**THEMATIC Research Field: DESIGN AND CONTROL OF AN EXTRANUMERARY LIMB FOR HUMAN-CENTRIC MANUFACTURING**

<b>Monthly net income of PhDscholarship (max 36 months)</b>
<b>€ 1500.0</b>
In case of a change of the welfare rates during the three-year period, the amount could be modified.

<b>Context of the research activity</b>	
<b>Motivation and objectives of the research in this field</b>	<p>Remanufacturing is the most valuable circular economy option, providing relevant economic returns to European manufacturing companies, contributing to the creation of knowledge-intensive jobs and new skills. However, modern high-added value consumer products manufactured in Europe are evolving into high-complexity smart products, embedding sensors and intelligence to provide an improved set of customized functions to users and to reduce the environmental footprint. This product transformation is posing additional burden on the implementation of safe, economically and environmentally attractive remanufacturing business cases aiming at reusing functions and materials from post-use high-added value products. The main objective of the remanufacturing process is to smooth the propagation of the product variability throughout the remanufacturing value-chain and factory stages. The quality requirements from the recovered parts are extremely demanding, since “as good as new” critical product characteristics have to be guaranteed. The regeneration rate in remanufacturing is usually between 50%-70%. The main limitations in the current remanufacturing practices include high-dependency on human activities with poor adoption of human-centered solutions. In spite of the massive dependency on human tasks, frequently complex, articulated and involving high loads, and knowledge-intensive decision making, specific technologies and tools in support of humans are poorly adopted in</p>



	<p>remanufacturing. The proposed research seeks to address these challenges by leveraging robotics and machine learning to enhance worker's safety and efficiency in disassembly processes, within the context of Industry 5.0.</p>
<p><b>Methods and techniques that will be developed and used to carry out the research</b></p>	<p><b>Phase 1</b> The candidate will start the research by delving into robotics and machine learning algorithms. On the one side, currently developed robotic systems for disassembly will be analyzed, with particular focus on wearable and collaborative solutions. On the other hand, machine learning approaches for robotic task learning and generalization will be analyzed. This phase will serve as a first step to understanding what is already available in the considered domain before designing ad hoc methodologies.</p> <p><b>Phase 2</b> Design and test of specific experimental protocols and metrics for ergonomic evaluation of workplaces and tasks, which could be used to identify critical situations to be specifically addressed (by wearable technologies, cobots or other solutions). The evaluation methodology will include a dedicated sensors network (i.e., evaluation toolkit): i) evaluation of the kinematic of the movement(s) by means of IMUs, ii) evaluation of muscular involvement, effort, and fatigue by means of EMG measurements; iii) evaluation of loads applied to most relevant joints by means of inverse dynamic calculation through simulation softwares (e.g., AnyBody); iv) evaluation of cognitive and systemic load by means of heart rate variability assessment.</p> <p><b>Phase 3</b> Design, development and on-field test of wearable extranumerary limb to mitigate the impact of fatigue on effort, attention and/or concentration level of the workers. Supernumerary limb solutions are at state-of-the-art edge and consists in a combination of a mechanical design, a sensor net with motion intention decoding algorithms, and a shared controller, in an effort to seamlessly integrate the additional limb with the target activity.</p> <p>This research project is carried out as part of the Horizon</p>



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<b>Educational objectives</b>	The PhD candidate is expected to develop solid competencies in robotics, mechatronics and machine learning. The candidate is also expected to acquire competencies in nonlinear dynamics, multi-physical modelling, and optimization algorithms. Contextually, strong coding skills in Matlab/Python/C++ will be gained.
<b>Job opportunities</b>	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared MSc holders in the same field. These job opportunities span various disciplines such as engineering, sustainability, material science, and project management, offering diverse career paths for individuals interested in advancing sustainable practices in the field of electric vehicle technology. Some partner universities are: Scuola Superiore Sant'Anna - Italy, and ETH Zurich - Switzerland.
<b>Composition of the research group</b>	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
<b>Name of the research directors</b>	Prof. Francesco Braghin, eng. Marta Gandolla

<b>Contacts</b>	
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<b>Additional support - Financial aid per PhD student per year (gross amount)</b>	
<b>Housing - Foreign Students</b>	--
<b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>	--

<b>Scholarship Increase for a period abroad</b>	
<b>Amount monthly</b>	750.0 €
<b>By number of months</b>	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 euro 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.