POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 40th cycle

THEMATIC Research Field: NONLINEAR AND MULTI-PHYSICAL PARAMETRIC AND TOPOLOGICAL OPTIMIZATION OF MEMS DEVICES

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 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	MEMS (Micro Electro-Mechanical Systems) industry has experienced significant growth in recent decades. Devices like microphones, PMUT, accelerometers, and gyroscopes have found applications in diverse areas such as smartphones, computers, and vehicles. The demand for these devices continues to rise, with increasing performance requirements and the need for smaller sizes.However, the current approach to MEMS design relies heavily on engineers' trial-and-error experience. This approach has several drawbacks: (i) it is user-dependent, (ii) it is time-consuming, and (iii) it primarily focuses on linear structural analysis, neglecting nonlinear dynamic phenomena and multi-physical effects like electrostatics and damping from fluid-structure interaction.In this research project, the goal is to develop an optimization framework for the design of MEMS devices. This framework will utilize parametric and topology optimization techniques and consider multiple physical domains. By adopting this approach, we aim to overcome the limitations of the traditional design process and achieve more efficient and optimized MEMS device design.
Methods and techniques that will be developed and used to carry out the research	The candidate will start the research by delving into parametric optimization, where the structure's topology is predetermined, and dimensions such as beam lengths and widths need to be determined based on some performance index. This phase will serve as an ideal

	performance index. This phase will serve as an ideal testing ground for developing and validating multi-physical models, e.g. encompassing mechanics and electrostatics, as well as nonlinear dynamical models utilizing reduced order models (ROMs). Drawing upon existing studies and software from our group, the candidate will devise strategies and codes to tackle the aforementioned challenges effectively.Then, the candidate will study topology optimization, where the structural shape isn't known beforehand but rather emerges from a solid block through “carving”. Special focus will be placed on density-based and level-set approaches, with an emphasis on the latter due to its notable advantages. Our group's recent efforts revolve around this method, collaborating with international partners to co-develop a dedicated software. The candidate will have the opportunity to develop new routines and features to address multi-physics problems and practical tools, including minimum and maximum dimension control.Finally, the optimization efforts will be focused towards individual component optimization, encompassing areas such as elastic suspensions and actuating electrode shape, as well as towards the optimization of complete systems, like accelerometers provided by our industrial partner, STMicroelectronics.Based on the outcome of the previous steps, a MEMS prototype will be produced and tested in our laboratory to validate the proposed methods.
Educational objectives	The PhD candidate is expected to develop a solid competence in optimization procedures for dynamical problems, and in particular on level-set approach. The candidate is also expected to acquire competencies in nonlinear dynamics, multi-physical modelling, and MEMS technology. Contextually, strong coding skills in Matlab/Python/C++ will be gained.
Job opportunities	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. List of Universities, Companies, Agencies and/or Nationalor International Institutions that are cooperating in

	the research include: STMicroelectronics; University of California San Diego; Delft Institute of Technology; ETH Zurich.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 2 PhD Students
Name of the research directors	Proff. Francesco Braghin, Jacopo Marconi

Contacts
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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	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, fundingfor participation in courses, summer schools, workshops and conferences) for a total amount of € 5.707,13. Our candidates are strongly encouraged to spend a research period abroad, joining high-levelresearch 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. 700 euro/month- net amount). Teaching assistantship: availability of funding in recognition of supporting teaching activitiesby the PhD candidate. There are various forms of financial aid for activities of support to theteaching practice. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.