POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 39th cycle

THEMATIC Research Field: METHODOLOGIES TO ENHANCE AUTONOMOUS SPACECRAFT GUIDANCE AND CONTROL

Monthly net income of PhDscholarship (max 36 months)
€ 1600.0 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	A new era in space is approaching fast. Soon, several miniaturised probes will permeate the inner Solar System, by targeting the abundantly variegated minor bodies in it. The space sector is enthusiastically embracing a new paradigm for space science and exploration, carried out by interplanetary CubeSats. Nevertheless, the current modus operandi can hamper this momentum: while the system development costs scale with its size, the same is not true for flight dynamics operations, which are still expensively performed from the ground, so requiring personnel and ground assets, which -at this pace- will soon saturate. Self-driving spacecraft are the solution: futuristic probes shall travel in a totally autonomous fashion, inferring their position from the surrounding environment and computing their guidance trajectory onboard. If proven feasible, this technology will boost large missions as well. Yet, while research on autonomous navigation techniques is advancing, progress on autonomous guidance is scarce. The state-of-the-art autonomous guidance and control algorithms do not guarantee acceptable levels of robustness, optimality, and sustainability. Sequential Convex Programming, direct, and indirect methods seem to be the most promising. Yet, there is a considerable gap to fill towards real, in-flight implementation. The main goal is shifting the guidance and control operations from ground to aboard CubeSats. Moreover, the challenge is to develop reliable guidance and control algorithms considering the skeletal budgets of

	nano-spacecraft. If successful, this technology will disrupt completely the way spacecraft are piloted towards their targets.
Methods and techniques that will be developed and used to carry out the research	The research aims at improving the state-of-the-art in real-time, onboard computed, guidance and control techniques. The PhD candidates will investigate the field, developing and implementing solutions that best fit the scenarios of interest. Possible research directions are: 1) the development of a custom solver for convex programming problems tailored to the limited-capability hardware available aboard CubeSats, and 2) the application of direct/indirect methods dedicated to onboard applications within the context of the convector mapping theorem. The work has to be carried out within the context of the ERC-funded EXTREMA project, where an integrated infrastructure has been developed to carry out hardware-in-the-loop experiments. Moreover, an in-house developed closed-loop six-degrees-of-freedom AOCS simulator will be adapted and extensively exploited for validating the proposed methodologies. Tests on relevant space hardware and processors are foreseen to assess the performance of the developed algorithms.
Educational objectives	The objective of this PhD is to develop skills in space system modelling and simulation as well as in autonomous guidance, navigation, and control. The candidate will gain relevant expertise in near-Earth and deep-space missions. Through this project, the candidates will develop skills in mathematical modelling, numerical analysis, computer programming (Matlab, Python, C++, or similar), and image processing. Moreover, the candidate will develop skills in both computer and processor/hardware-in-the-loop simulations. Soft skills in disseminating the research, writing reports, performing outreach, and preparing industrial progress meetings will be also achieved through the PhD project.
Job opportunities	The current research prepares the PhD candidate for both academic and industrial careers. Knowledge of model-based system engineering, modelling and simulation of

	space systems, as well as autonomous guidance, navigation, and control are fundamental skills for careers in space-related companies and universities.
Composition of the research group	1 Full Professors 1 Associated Professors 2 Assistant Professors 20 PhD Students
Name of the research directors	Prof. Francesco Topputo

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	800.0 €
By number of months	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
The PhD candidate will receive a desk, possibly through a hot-desking procedure, and a personal computer, if needed. Apart from the compulsory ones, the PhD candidate will have the opportunity to follow additional courses and receive economic support to attend summer schools and participate in conferences. There will be the possibility of paid teaching assistantship.