POLITECNICO DI MILANO

PhD in INGEGNERIA AEROSPAZIALE / AEROSPACE ENGINEERING - 40th cycle

THEMATIC Research Field: AUTONOMOUS AI-AIDED RELATIVE NAVIGATION TO UNCOOPERATIVE TARGETS

Monthly net income of PhDscholarship (max 36 months)
€ 1700.0 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	Novel space mission concepts require more autonomy to decrease cost and fulfil the mission objectives. Explorations of asteroids and in-orbit servicing strongly motivate the development of autonomous and low-latency solutions to determine the spacecraft state with respect to an uncooperative target. Wrong determination of the target-spacecraft state could be mission critical, leading to possible risks and fatal collision with the target. State-of-the-art radiometric tracking cannot provide the spacecraft real-time information about its state with respect to the target, due to radio signal propagation delays. All in all, new methodologies for determining and controlling the orbit of spacecraft must be devised to enable close proximity operation in challenging scenarios. To do so, machine learning has been proven as an effective and promising methodology to be synergically used along with model-based techniques. The objective of this PhD project is to advance the state of the art in autonomous navigation in close proximity by exploiting AI-based and model-based techniques. The aim is to develop technologies for close proximity applications, image processing, and autonomous navigation in view of the typical requirements of close proximity missions. The technologies will be tested in numerical simulations and then in hardware-in-the-loop simulations. This is to verify the requirements and increase the developed solution TRL in view of applicability in future close proximity operations.

Methods and techniques that will be developed and used to carry out the research	The proposed project has the ambition to 1) enable autonomous navigation of space platforms and 2) develop and validate AI-based techniques for close proximity applications. The idea is to develop novel autonomous navigation techniques for space systems based on AI-based solutions and model-based approaches. Disciplines in space mission simulation, image rendering, image processing, on-board filtering, and hardware-in-the-loop simulations will be key building blocks for autonomous navigation in close proximity. A particular focus will be devoted to AI-based methodology and its combination with model-based navigation filters. The PhD programme is organized in different phases: 1) Review of navigation methods for space missions and image processing; 2) Definition of autonomous navigation simulation scenario in view of typical requirements of close proximity missions; 3) Design of autonomous navigation systems for close proximity mission; 4) Implementation of autonomous navigation architecture into a mathematical/numerical simulation environment in view of their embeddability; 5) Simulation and performance analysis of autonomous navigation system in numerical environment and iterative feedback on developed design; 6) Implementation of autonomous navigation architecture into hardware-in-the-loop simulation environment; 7) Performance analysis of autonomous navigation architecture in HIL simulations. The proposed PhD project combines renowned expertise in the field of image processing, navigation filtering, and their combined integration to achieve autonomous navigation in close proximity.
Educational objectives	The objective of this PhD is to develop skills in vision-based navigation algorithm development, as well as their testing and validation. The candidate will gain relevant expertise in close proximity operations and navigation scenarios. 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 on both numerical and hardware-in-the-loop simulations. Soft skills in disseminating the research,

	writing reports, performing outreach, and preparing progress meetings will also be achieved through the PhD project. These educational objectives will also be acquired through secondments in relevant actors of the field. During this period, the PhD student is supposed to spend 18 months in a foreign university/research centre/company.
Job opportunities	The current research prepares the PhD candidate for both academic and industrial careers. Knowledge of machine learning, onboard filtering, image processing, image generation and space system simulation 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. Paolo Panicucci

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	850.0 €
By number of months	18

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.


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