AEROSPACE ENGINEERING

CRT/DIMEAS - Real-Time Control and Navigation of UAVs with Flexible Manipulators for Precision Environmental Applications

Funded By	Dipartimento DIMEAS FONDAZIONE CRT CASSA DI RISPARMIO DI TORINO [P.iva/CF:06655250014]
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Context of the research activity	This project proposes the development of an alternative drone platform featuring integrated flexible robotic arms, merging advanced mechanical design with intelligent navigation systems.
Objectives	This project proposes the development of an alternative drone platform featuring integrated flexible robotic arms, merging advanced mechanical design with intelligent navigation systems. The objective is to overcome the operational limitations of conventional aerial platforms by enabling physical interaction with complex and dynamic environments while maintaining flight stability and energy efficiency. Indeed, the use of flexible robotic arms expands the drone's functional range by enhancing manoeuvrability and mission versatility. Flexible robotic appendages introduce non-negligible effects as variable load distributions and time-varying structural dynamics, which must be accounted for within the control loop. Immersive, hardware-in-the-loop simulation environments will support the development of adaptive navigation and control algorithms, to manage the coupled dynamics of the aerial vehicle and its articulated appendages in real time. This necessitates the development of multi-modal models and control strategies capable of handling structural uncertainty and ensuring robust trajectory tracking and stability. The platform will leverage distributed and cooperative localization frameworks to maintain robust situational awareness in GPS-denied or communication-constrained environments. The resulting system architecture will be inherently scalable, enabling extension to multi-agent aerial teams for collaborative manipulation or area coverage tasks—opening the road for decentralized coordination and shared environmental mapping. The methodology is deeply interdisciplinary, combining elements from mechatronics, artificial intelligence, soft robotics, and applied aerodynamics. Potential applications include environmental monitoring, such as the detection of plant diseases and ecological assessment in hard-to-reach

	areas. The project also aims to define a modular design framework, facilitating adaptation to various industrial, civil, and environmental use cases. Through a synergy of advanced robotics and intelligent control, the proposed drone system represents a transformative step toward multifunctional, environmentally conscious aerial robotics.

Skills and competencies for the development of the activity	Knowledge of sensors for UAV systems, familiarity with drones, understanding of control theory, basic proficiency in Python, ROS, and C++.