POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 39th cycle

Research Area n. 3 - Systems and Control

PNRR 118 PNRR Research Field: AUTONOMOUS NAVIGATION IN UNCERTAIN DYNAMIC ENVIRONMENTS OF A DRONE FLEET FOR COLLABORATIVE AGRICULTURAL TASKS

Monthly net income of PhDscholarship (max 36 months)
€ 1400.0
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	The PhD project aims at developing algorithms for autonomous navigation of a UAV fleet in partially known complex environments, in the presence of static and dynamic obstacles, while carrying static and dynamic loads whose presence may cause significant disruptions to flight dynamics. Inspired by the challenges encountered in the application of UAVs to the agricultural domain, cooperative control and aggregation strategies for the navigation in complex/dynamic environments and the transportation of objects whose inertial properties may vary over time are developed. Among the many possible applications of UAVs to agriculture, two case studies are considered, particularly relevant in terms of complexity and impact on the sustainability of the Italian agriculture.The first case study concerns phytosanitary treatment of a vineyard, by spraying from an UAV. This application has a particular relevance where execution of phytosanitary treatments has a significant impact on production, economically or due to lack of manpower. A typical example is terraced viticulture, that plays a fundamental role both economically, in defining the landscape, and in ensuring hydrogeological stability, but a gradual decrease in available labour and rising costs are causing terraced crops to be progressively abandoned. The use of UAVs for phytosanitary treatments

	represents an important opportunity also for hilly territories characterized by steep slopes, where treatments are nowadays carried out with the use of tractors. In today's increasingly common case of organic farming, the time windows in which treatments must necessarily be carried out are very short, and it is therefore necessary to carry them out even if soil conditions (e.g., due to rainfall) are not safe and may cause tractor rollover. The use of UAVs would result in an easier way to carry out treatments, with a larger spread of organic farming and a lower social cost associated to potential accidents.The second case study concerns monitoring and performing treatments to spatially extensive crops for, e.g., processing tomatoes, of which Italy is one of the main producers in Europe. The large extent of the crop does not allow agronomists to carry out precise monitoring of the entire crop, but only spot checks on some areas, making a timely detection of diseases more difficult. The use of UAVs allows continuous monitoring of larger areas, or even the entire crop, easing disease detection and a timely intervention. In turn, this limits the use of products potentially harmful to the environment. On the other hand, the ability to promptly identify diseases and pests is one of the preconditions for promoting the spread of organic farming. Finally, the use of UAVs for the shedding of insects as biological control agents, both in organic farming contexts and in integrated pest management methods, is also of interest for these crops.
Methods and techniques that will be developed and used to carry out the research	The PhD project will have two deeply connected components: a theoretical one and an experimental one, with the goal of developing novel advanced approaches for agricultural applications and testing them in real-world scenarios. The theoretical methods will involve nonlinear and optimization-based approaches to address the problems arising in fully autonomous navigation in partially uncertain and time-varying environments. Such problems include offline planning, real-time re-planning, reactive obstacle avoidance, adaptive mapping, for a fleet of units. Regarding the experimental activity, it will be carried out

	using the devices available at the Safe Autonomous Systems Laboratory at DEIB, currently comprising 1 hexacopter and 2 octacopters with the possibility to install various sensors (lidars, 3D cameras) and implement ad-hoc high-level control systems. Furthermore, the Robotics Sensor Technologies for Environment and Agriculture lab at Cremona Campus will be available to perform preliminary indoor testing activities, exploiting a newly installed motion capture system, and to provide contacts with farmers for field tests.
Educational objectives	The PhD candidate is expected to gain a deep knowledge on modelling, simulation, and experimental testing of autonomous drones, on methodologies for navigation and obstacle avoidance, as well as distributed and centralized techniques to coordinate a fleet of drones. Moreover, application-related knowledge in the domain of agriculture will be obtained. Finally, since the developed methods will rely upon numerical optimization and switched control approaches, a strong training in these domains is envisioned as well.
Job opportunities	Upon completion of the PhD program, the candidate will have work opportunities in various industrial domains, such as robotics-assisted agriculture, autonomous vehicles, drone development and drone-based services. Based on the results of the research, a technology transfer activity such as founding a start-up company may also be triggered. Finally, the methodological topics of the project will also make it possible to pursue an academic career.
Composition of the research group	2 Full Professors 3 Associated Professors 3 Assistant Professors 2 PhD Students
Name of the research directors	Luca Bascetta

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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	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	
By number of months at the company	0
Institution or company where the candidate will spend the period abroad (name and brief description)	Ecole Polytechnique Fédérale de Lausanne
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
EDUCATIONAL ACTIVITIES (purchase of study books and material, including computers, funding for participation in courses, summer schools, workshops and conferences): financial aid per PhD student   TEACHING ASSISTANTSHIP: availability of funding in recognition of supporting teaching activities by the PhD student 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.   COMPUTER AVAILABILITY: individual use   DESK AVAILABILITY: individual use