



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

Research Area n. 3 - Systems and Control

**PNRR 118 PA Research Field: A SOIL FRIENDLY PLATFORM FOR VINEYARD
APPLICATIONS**

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 last decade has been characterized by an increasing interest in agricultural robotics, from a scientific and commercial point of view. Considering the production of commercial robots, many of them, including land and aerial robots, are now available on the market (e.g., AGRAS MG-1, T16, and P4 drones, Vitirover mower, Dino weeding robot, Winnica vineyard robot). At the same time a significant number of European projects on agricultural robotics have been founded (e.g., ROBS4CROPS, FLEXIGROBOTS, BACCHUS, FLOURISH, GRAPE).

Almost all funded projects, however, are focused on perception for navigation or task execution, planning, control, or use of artificial intelligence to increase autonomy, assuming the robotic platform as a facility already available on the market. This being apparently in contrast with the huge efforts devoted by commercial manufacturers on platform design, and on the difficulties emerging from the experimental validation in many research projects.

This research, instead, focuses on robot design and, in particular, on locomotion system design, i.e., a part of the platform that is crucial to guarantee a safe and efficient navigation especially in the presence of difficult terrains, e.g., hilly or with steep slopes, or poorly traversable terrains, as it happens in the heroic viticulture of some



	<p>important Italian regions. Furthermore, a Copernican revolution in locomotion system design is adopted, shifting the main design requirement from maximizing traction forces to achieving the required traction force without inducing permanent changes in soil state and hydraulic properties, so as to avoid detrimental effects on the functionality of plant root systems, and to decrease the environmental impact caused by surface water dynamics and soil erosion.</p> <p>As a result, this research aims at producing an experimentally validated simulator that allows to support the mechatronic design of a newly conceived locomotion system or the analysis of an existing one, quantifying permanent changes in soil state and hydraulic properties it can produce.</p> <p>This innovative PhD covers the CUN Disciplinary Area 09 - Industrial and Information Engineering and is multi-disciplinary in nature involving control theory, optimized mechatronic design, mechanical systems and soil modelling. The PhD fully meets the priorities of Italy's National Recovery and Resilience Plan (PNRR), as it is aimed at fostering the digital transition of PA bodies involved in agricultural research, contributing to the adoption of the most suitable digital technologies and solutions to ensure a more effective and efficient action of these bodies in providing consulting services aiming at developing soil friendly agricultural robots for vineyard applications.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The research is characterized by a theoretical development and an experimental activity, with the aim of designing a novel locomotion system for an agricultural robot and developing the corresponding simulation. The theoretical methods include modelling the locomotion system, the soil mechanical properties and soil-platform interaction, and the optimized mechatronic design of the locomotion system, including the velocity/torque control system.</p> <p>The experimental activity will be carried out using the devices available at the Robotics Sensor Technologies for Environment and Agriculture lab at Cremona Campus, currently including 3 tracked and 1 wheeled mobile robot</p>



	<p>with the possibility to install various sensors (lidars, 3D cameras, GPS) and implement ad-hoc high-level control systems, and 1 prototype of wheeled mobile robot with the possibility to implement ad-hoc low-level control systems for wheel velocity and torque control.</p> <p>Additional research activity will be carried out with the support of the CREA research facilities, in order to characterize mechanical and hydraulic properties of typical vineyard soils, before and after the changes performed by a robot.</p>
Educational objectives	<p>The PhD candidate will gain a deep knowledge on modelling and simulation of the locomotion system of a robot for agricultural tasks, including soil modelling and soil-platform interaction, and optimized mechatronic design. In particular, as the design will be based on a combined numerical optimization of the mechanical and control system, a strong training in these domains is envisioned as well.</p>
Job opportunities	<p>As a result of the PhD program, the candidate will have job opportunities in different domains, including mechanical design and control system design for mobile robots and autonomous vehicles, development of robot-assisted technologies for agriculture, and of services to assess the environmental impact of newly designed and existing agricultural robots and machinery. A technology transfer activity, e.g., founding a start-up company, may be also envisaged as a result of the research. Finally, the methodological tools developed during the PhD will also allow to pursue an academic career.</p>
Composition of the research group	<p>1 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students</p>
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)	Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CREA)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Virginia Polytechnic Institute and State University
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
<p>UGVs can ensure an economically and environmentally sustainable future for important crops, such as terraced and hillside vineyards. The research will develop methodologies for modelling and optimised mechatronic design of the locomotion system of a UGV for agricultural use, considering both the ability to navigate difficult terrain and the environmental impact, i.e., on soil mechanical properties, that such a system may have.</p> <p>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.</p> <p>TEACHING ASSISTANTSHIP: availability of funding in recognition of supporting teaching activities by the PhD student.</p> <p>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.</p> <p>COMPUTER AVAILABILITY: individual use.</p> <p>DESK AVAILABILITY: individual use.</p>