POLITECNICO DI MILANO

PhD in INGEGNERIA AMBIENTALE E DELLE INFRASTRUTTURE / ENVIRONMENTAL AND INFRASTRUCTURE ENGINEERING - 39th cycle

Research Area n. 3 - Environmental and Hydraulic Engineering and Geomatics

PNRR 118 TDA Research Field: MULTISPECTRAL AND THERMAL SENSORS ONBOARD UAV TO MONITOR WATER STATUS IN VINEYARDS

Monthly net income of PhDscholarship (max 36 months)
€ 1195.5
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	In agriculture an efficient management of water and nutrients is fundamental to make crop production sustainable both for environment and economics. Precision Agriculture (PA) is a set of practices that sees recently great improvements due to increased capability of digital data storage and processing, in parallel with growing environmental needs. PA practices require a detailed description of the field variability of soil and plant properties to apply water and nutrients at variable rates. Many techniques and instruments have been developed and tested to study the within-field variability for different crops. The great development of monitoring technologies and data processing, from digital images by UAV or satellites to ground data, provide a huge amount of data, fundamental if properly exploited. It is nowadays well assessed that many farms could have financial advantages by applying precision agriculture criteria, saving water, fertilizers and energy, and reducing water and soil pollution with simultaneous environmental benefits. Nevertheless, the complexity in the use of new instruments and in the processing can still represent an obstacle for their use. Moreover, the variety of farm characteristics (types of crops and extension, ground morphology, etc.) requires specific solutions of survey and

POLITECNICO DI MILANO

	morphology, etc.) requires specific solutions of survey and data processing that are far from being well assessed and commonly adopted. In Viticulture data coming from ground, drone, and satellite surveys can be used to define specific homogeneous management zones (SMZ) to optimize site-specific inputs, maintaining or enhancing yield quantity and quality. Various projects were developed recently in cooperation with the Dept. of Agricultural and Environmental Science of Università degli Studi di Milano (DiSAA), testing different approaches of data fusion, for a better definition of SMZ, to optimize irrigation in crops and to provide water stress and vegetation indices. Data from geophysical surveys, UAV and Satellite multispectral and thermal sensors were compared and integrated. Now there is the need to organize in an optimized workflow the wide range of experimented techniques, to propose effective procedures and digital instruments that farmers can use to modernize agricultural practices; guidelines and tools must be developed to support the production of quantitative maps for a better irrigation input management. The objective of the research consists in developing and optimizing a machine learning model for a high resolution mapping of water status of vine, combining ultra-high resolution images and agro-meteorological data acquired on experimental vineyards. The experimental work will be carried out with DiSAA-UNIMI, expert in irrigation management and surveying of soil-crop system water status.The project is aligned with the declared objectives of PNRR 2021-2027 (also according DM 118 02/03/2023) and in particular with research themes M2C1 (Sustainable Agriculture) and M2C4 (Safeguard of Water Resource)
Methods and techniques that will be developed and used to carry out the research	1. Analysis of multispectral and thermal images acquired by a UAV to select the more suitable spectral and thermal indices for water-status monitoring in vineyard. During the agricultural seasons 2024 and 2025, three experimental vineyards in the Franciacorta (BS) area will be surveyed with four UAV flights, and simultaneous ground measurements will be collected (crop water potential, IR temperature). The indices will

	be tested in robustness and capability to predict ground water stress indices. 2. Development and comparison of machine learning models to integrate UAV images and agro-meteorological data for a better prediction of ground water stress indices, with the final purpose of providing irrigation prescription maps. 3. Compare results with those provided by high resolution satellite imagery (e.g., PlanetScope or WorldView), possibly integrated with UAV imagery, in order to map water stress on larger scales, reducing the UAV surveys and the post processing effort. The research will be carried out in cooperation with DiSAA-UNIMI team, who has a deep and long-terming experience in the monitoring of the water status of agro-ecosystems through soil-plant sensors, and in their simulation through agro-hydrological modelling. The outputs of the research will consist both in digital tools implementing the studied methodologies, and in guidelines to use them.
Educational objectives	The educational objectives are: 1) deep knowledge of objectives and methodologies of precision irrigation (PI) in viticulture and, more in general, in agriculture; 2) deep knowledge of the different survey techniques and satellite data suitable to be used in PI; 3) synergic use of these data and machine learning models to develop new products to be used in PI.
Job opportunities	The Doctor will exploit the acquired skills in: - private companies that provide consultancy to farms for the implementation of precision farming techniques; - large farms that have technicians who develop innovation in agriculture in their staff (e.g. Bonifiche Ferraresi) - Remote Sensing and UAV survey related jobs.

Composition of the research group	0 Full Professors 1 Associated Professors 1 Assistant Professors 1 PhD Students
Name of the research directors	Giovanna Sona

Contacts
giovanna.sona@polimi.it

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	597.75 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	Consorzio Tutela del Franciacorta (https://franciacorta.wine/it/)
By number of months at the company	8
Institution or company where the candidate will spend the period abroad (name and brief description)	To be defined
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Cooperations: Universities, Companies, and/or National or International Institutions that are cooperating in the research:

.

.

•Università degli studi di Milano, Dipartimento di Scienze Agrarie e Ambientali (DiSAA-UNIMI)

.

Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): approximately 1630,00 euros per PhD candidate per year, on average.

Teaching assistantship (availability of funding in recognition of support to 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.

POLITECNICO DI MILANO

Computer availability and desk availability: individual assignment for the entire career.