POLITECNICO DI MILANO

PhD in INGEGNERIA DELL'INFORMAZIONE / INFORMATION TECHNOLOGY - 40th cycle

Research Area n. 1 - Computer Science and Engineering

PNRR 630 Research Field: 3D MODELING AND MONITORING IN COMPLEX INDUSTRIAL ENVIRONMENTS

Monthly net income of PhDscholarship (max 36 months)
€ 1500.0 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	A long-term goal of computer vision is to develop algorithms able to perceive and digitize the 3D world as capturedby imaging sensors. Strong results have already been achieved in 3D modeling, for example, Simultaneous Localization and Mapping (SLAM) and Structure From Motion (SfM) are mature technologies that have been successfully applied in a wide range of applications. However, these methods rely on simplifying assumptions on thescene (e.g., well-lit scenes with few static objects and without clutter and occlusions) that are not typically met inindustrial environments characterized by cluttered scenes with multiple interacting entities. The PhD student will address one of the next research challenges in computer vision: the automatic modeling and monitoring of complex industrial environments. This requires the design of novel algorithms that exploit the information coming from the environment as well as the geometric constraints imposed by the acquisition settings to improve the 3D modeling of a scene. Specifically, the research must integrate into a unifying framework - *geometric methods*: to achieve accurate metric 3D reconstruction from a few images acquired in a real world scenario of a known target (e.g. a cylindrical pipe in a manufacturing plant). Robust fitting techniques will be

	developed and extensively used to associate a 3D geometric primitive to the 2D views and provide an additional regularization in learning problems. - *self-supervised learning methods*: in many industrial settings, extensive labeling for training deep learning modelsis very time consuming and prohibitive when it is required to annotate multiple times in multiple settings. However, in some situations humans involved in the industrial processes can provide annotation but in an unconventional form for existing machine learning models. For example, in waste sorting plants, humans are selecting materials that are moving on trays, thus it is in principle possible to learn the selection criteria (to possibly assist the operator within anautomatic monitoring tool) by comparing images before and after human intervention. Unfortunately, there are nolearning frameworks able to take advantage of this form of supervision. Learning from such a mild form of supervision can significantly boost the use of deep neural networks in industrial monitoring. - *statistical methods*: for detecting anomalous situations with respect to normal operating conditions. - *explainability techniques*: to account for defects and anomalies, elucidating the causes of failure. These techniques facilitate operator intervention and improve overall system reliability by explaining occurred problems. This research opens new frontiers in the reconstruction of industrial scenes from sparse images and has the potential to inspire new research directions in virtual reality, machine vision, and autonomous driving.
Methods and techniques that will be developed and used to carry out the research	The candidate will i) survey the literature for image-based 3D modeling and self-supervised learning from visual data. ii) investigate new approaches and algorithms for identifying and monitoring multiple moving objects and enforce 3D geometric constraints in these settings. To this purpose, the candidate will develop a blend of Deep Learning models for visual recognition and traditional Computer Vision algorithms. iii) Explore the use of explainability techniques to make potential malfunctions intelligible and allow for operator intervention.

Educational objectives	The research activity will be grounded in Machine Learning and Computer Vision. The candidate will develop strong modeling skills to tackle research challenges from a formal perspective, providing a clear and unique mathematical description of the addressed problems. The candidate will also acquire strong engineering and programming skills(Python, MATLAB and penCV), together with proficiency in technical writing and communication. The research outcomes will be possibly applied to solve real-world industrial problems.
Job opportunities	The job market is seeing an increasing need for expertise in computer vision. At completion of the PhD program, the candidate could see himself involved in several industries designing CV systems for quality inspection and monitoring. The company sponsoring the PhD has excellent skills in translating cutting-edge research into practical industrial applications, exemplifies such opportunities.
Composition of the research group	0 Full Professors 1 Associated Professors 2 Assistant Professors 10 PhD Students
Name of the research directors	Luca Magri

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	750.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	KAYRHOS S.r.l. (Milano)
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Czech Technical University in Prague (Dejvice, Czech Republic)
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:
1st year: Yes
2nd year: Yes
3rd year: Yes