POLITECNICO DI MILANO

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

Research Area n. 2 - Electronics

PNRR 117 Research Field: METHODS AND TECHNIQUES FOR NON-LINE-OF-SIGHT VISION SYSTEMS AND IMAGING WITH SINGLE-PHOTON DETECTORS

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	Non-Line-of-Sight (NLOS) imaging exploits time-of-flight of single photons scattered from objects hidden from the camera's direct line of sight for reconstructing their images. It can be considered as an evolution of the single-photon LiDAR (light detection and ranging), where a line-of-sight scene is reconstructed in 3D by measuring the time of flight of single photons emitted by a pulsed source and reflected by the scene. Single-photon LiDAR is currently under development for many different applications, from consumer electronics (e.g., smartphones) to the automotive field (for ADAS systems), from security applications to environmental monitoring (e.g., gas leakage detection). In the first experimental demonstrations of NLOS imaging, the single-photon detectors were based on silicon SPAD arrays and the light sources were pulsed lasers operating in the visible range. While such initial trials were useful for the first experimental proof of concept in the laboratory, next generation NLOS imaging systems have to operate in the short-wave infrared (SWIR) wavelength ranges for avoiding any issue with people health (the system has to be eye-safe) and also for operating at non-visible wavelengths, thus making such systems more difficult to be detected in critical environments. This research project aims to develop both a SWIR

	single-photon LiDAR system and a SWIR NLOS one, where the laser wavelength is longer than 1 μm and the single-photon detector is based on InGaAs/InP SPAD (Single Photon Avalanche Diode) arrays specifically designed for eye-safe imaging applications. After designing and assembling the LiDAR and NLOS setups, experimental data will be acquired and processed, in order to extract images (and, possibly, videos) of the objects from the time-of-flight information.
Methods and techniques that will be developed and used to carry out the research	The PhD candidate will have to model and design the whole electro-opto-mechanical experimental setups for single-photon LiDAR and NLOS imaging, by selecting the more appropriate laser source, SPAD-based single-photon detector, galvo-mirror, optics, control/acquisition software, etc., in order to build the full experimental systems. In detail, if needed the SPAD-based detector will be customized by developing bespoke sub-systems. A personal computer will control the full system and will acquire the time-of-flight data. In order to properly analyze light scattered from multiple surfaces along indirect paths, with the goal of revealing the 3D shape and visual appearance of objects outside the direct line of sight, the PhD candidate will develop new algorithms and computational techniques for extracting the data of interested from the huge number of background photons and thus reconstruct the images from the time-resolved indirect light transport information.
Educational objectives	The PhD student will learn how to model, simulate, design, prototype and characterize optoelectronic systems operating at single-photon level. The PhD student will also have the possibility to further develop single-photon detection systems based on SPADs, by developing new electronic systems (including electronic boards, microcontrollers, FPGAs, etc.). The PhD student will develop methods, algorithms, computational techniques, and codes (including graphical-user-interfaces to enable users to manage and control the experimental systems) for reconstructing the scenes. The doctorate activity will include attendance of academic courses, conferences, summer schools and workshops.

Job opportunities	The PhD studies will allow to acquire all required skills and know-how to enable a swift transition to high-level R&D companies and institutes. Besides the company Leonardo involved in this project, the POLIMI's research group has already many contacts with R&D centers and end-users, which employed previous PhD students and post-docs, trained in the research group.
Composition of the research group	1 Full Professors 2 Associated Professors 0 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Alberto Tosi

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	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)	LEONARDO S.P.A.
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	University of Wisconsin - Madison
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