POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 39th cycle

PARTENARIATO PNRR Research Field: METASURFACE-ENHANCED LIDAR TECHNOLOGY

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	Autonomous systems, such as autonomous cars and robotic manipulators, rely on multiple transducers to sense their surrounding environments and, in particular, optical ranging sensors have been conceived to provide vision to such systems. In this context, Light Detection and Ranging technology (LiDAR) is commonly used to make high-resolution 3D digital maps. Conventional LiDARs leverage on time-of-flight measurement, which consists of a pulsed laser pointed toward a target object and allows measuring the forward-to backward propagation time of light pulses from the laser to the scanned scene and back to a detection module. In other words, 3D objects present in the environment are detected point-by-point by measuring the ToF from every probed direction to build an optical echo map. Today, industrially relevant LiDARs mainly use macro-mechanical systems to scan the entire 360° Field of View. A scanning LiDAR system is made of a light source for illumination, a scanning module for fast beam direction at different points in the scene, and a detection module. Besides their large FoV, these bulky systems present limited imaging rates of the order of a few tens of Hz. Recently, metasurfaces (MS) have spurred the interest of the research community by unveiling the possibility of engineering the properties of light at will, such as amplitude, phase, frequency, and polarization. MSs are flat components made of arrangements of unit cells of subwavelength size and periodicity tailored to produce a certain functionality after fabrication. By

	properly selecting the size and the spacing of the meta-atoms, MSs allow to redirect a laser beam at any arbitrary but fixed angle dictated by the generalized Snell's law. Dynamic MSs designed by materials possessing tunable properties generated by external stimuli are promising solutions for real-time wave steering and scanning, whereby the array of meta-atoms is actively controlled to produce a large phase shift to the incident wave, providing a huge potential for arrayed two-dimensional active optics/acoustics. The focus of this research is to perform cutting-edge research on tunable MSs, with the goal of designing a device capable of real-time imaging over a broad FoV using electromagnetic or acoustic waves. Both spatially modulated and time-modulated metasurfaces will be considered to broaden the available degrees of freedom in the underlying wave steering mechanism. The research activity is financed by the Sustainable Mobility Center (*Centro Nazionale per la Mobilità Sostenibile* - CN MS), Spoke 6 (Connected and autonomous vehicle - *Guida autonoma e veicolo connesso*) CN00000023, as part of the National Plan for Recovery and Resilience (PNRR, M4 C2 Dalla ricerca all'impresa, Investimento 1.4), finanziato dall'Unione Europea - Next GenerationEU. CUP D43C22001180001 - D.D. 1033 del 17/06/2022; D.D. 3138 del 16/12/2021 rettificato con D.D. 3175 del 18/12/2021.
Methods and techniques that will be developed and used to carry out the research	This research will be focused on the implementation of a metasurface able to convert and steer impinging waves into a beam with large FoV and with technologically relevant imaging capabilities. Following the duality between acoustics and photonics, the implementation will be carried out at first in the realm of acoustics. This task requires a deep understanding of the underlying physics as well as numerical skills in the context of electromagnetic/acoustic metasurfaces. The exploration of new metamaterials functionalities will be carried out by way of multi-physics FEM techniques, Plane Wave Expansion Methods (PWEM) applied to simplified models emerging from generally accepted kinematic assumptions. These methods will be suitably modified to embody

	complex network (local, nonlocal) interactions, time-dependent interactions, and tunable properties, which in general allow to provide richer dynamics as compared to the linear time-invariant counterparts. Finally, rigorous experimental methods will be implemented on table-top experiments, where the PhD students will be able to measure the expected transient and steady-state phenomena associated to wave propagation.
Educational objectives	It is expected that both analytical and experimental techniques will be mastered before the end of the PhD program. The PhD candidate will be able to conceive and carry out cutting-edge research both autonomously and in a team. High-level scientific training will be provided, fostering and refining research and problem-solving abilities.
Job opportunities	Our last survey on MeccPhD Doctorates highlighted a 100% employment rate within the first year and a 35% higher salary compared to Master of Science holders in the same field.
Composition of the research group	1 Full Professors 0 Associated Professors 1 Assistant Professors 0 PhD Students
Name of the research directors	Prof. Francesco Braghin, Eng. Emanuele Riva

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

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information
Financial aid is available for all PhD candidates (purchase of study books and materials, funding for participation in courses, summer schools, workshops and conferences) for a total amount of euro 5.707,13. Our candidates are strongly encouraged to spend a research period abroad, joining high-level research groups in the specific PhD research topic, selected in agreement with the Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approx. 700 euro/month- net amount). Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. 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.