



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

Research Area n. 3 - Systems and Control

**PNRR 630 Research Field: SAFE NAVIGATION PLANNING OF MOBILE ROBOTS IN
UNSTRUCTURED ENVIRONMENTS SHARED WITH HUMANS**

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

Mobile robots are increasingly being deployed in unstructured environments alongside humans, but safe navigation in these dynamic settings presents significant challenges. This PhD project proposes a novel integrated approach for safe navigation using sensor fusion, i.e., combining camera data, LiDAR (Light Detection and Ranging), and proximity sensors, to create a comprehensive understanding of the robot's surroundings, to identify and classify obstacles, including both static elements and dynamic human presence, to estimate pedestrian motion patterns and intentions, while explicitly taking uncertainty into account.

The research mainly focuses on the development of a planning and tracking strategy to support safe navigation in human crowded environments, complementing the architecture with suitable Simultaneous Localization and Mapping (SLAM) techniques.

The distinguishing elements of this approach, shared by the planner and the tracking controller, are:

- 1.The inclusion of a pedestrian motion model, allowing to forecast the near future trajectory performed by each human, in terms of both position and velocity.
- 2.The adoption of a model of the environment that



	<p>includes uncertainty (in particular, for the pedestrian future positions and velocities), and of planning/tracking strategies that leverage on this model to guarantee safe navigation and obstacle avoidance.</p> <p>3.The development of a navigation system that takes human psychological comfort into account, respecting social rules, ensuring a comfortable shared space, and minimizing disruptions to human activities.</p> <p>4.The development of efficient algorithms able to cope with a highly dynamic environment.</p> <p>Extensions of these navigation functionalities to a multi-agent scenario, where 2/3 robots collaborate to map, plan or control in a distributed way are also considered.</p> <p>The evaluation of the proposed approach will involve simulations and real-world deployments within unstructured environments populated by humans. The success will be measured by the robot?s ability to navigate safely and efficiently within the shared space. This research has the potential to significantly advance the safe and seamless integration of mobile robots into our everyday lives.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The PhD project has two deeply connected components: a theoretical one and an experimental one, with the goal of developing novel advanced approaches for safe autonomous navigation of mobile robots in human crowded scenarios. The theoretical methods involve optimization-based and sampling-based approaches to address planning and tracking problems arising in fully autonomous navigation in partially uncertain and dynamic environments.</p> <p>Regarding the experimental activity, it will be carried out using the devices available at DEIB and Leonardo company laboratories, ranging from autonomous electric wheelchairs to dog robots.</p>
<p>Educational objectives</p>	<p>The PhD candidate is expected to gain a deep knowledge on modelling, simulation, and experimental testing of autonomous mobile robots, on methodologies for autonomous navigation and obstacle avoidance.</p>



	<p>Moreover, application-related knowledge in the domain of navigation in crowded environments will be obtained.</p> <p>Finally, since the developed methods will rely upon optimization-based control approaches and sampling-based planning approaches applied to deterministic and stochastic models, a strong training in these domains is envisioned as well.</p>
Job opportunities	<p>Upon completion of the PhD program, the candidate will have work opportunities in various industrial domains, such as autonomous vehicles, personal mobility devices, service robotics. Based on the results of the research, a technology transfer activity such as founding a start-up company may also be triggered. Finally, the methodological topics of the project will also make it possible to pursue an academic career.</p>
Composition of the research group	<p>2 Full Professors 1 Associated Professors 2 Assistant Professors 3 PhD Students</p>
Name of the research directors	Prof.Luca Bascetta

Contacts	
<p>luca.bascetta@polimi.it - 0223993440 - https://www.deib.polimi.it/ita/personale/dettagli/81242</p>	

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)	Leonardo Labs, Genova, Italia
By number of months at the company	12
Institution or company where the candidate will spend the period abroad	Chalmers University of Technology, Göteborg, Svezia



candidate will spend the period abroad (name and brief description)	
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information	
<p><u>EDUCATIONAL ACTIVITIES</u> (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><u>TEACHING ASSISTANTSHIP:</u> 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.</p> <p><u>COMPUTER AVAILABILITY:</u> 1st year: Yes 2nd year: Yes 3rd year: Yes</p>	