POLITECNICO DI MILANO

PhD in INGEGNERIA MECCANICA / MECHANICAL ENGINEERING - 41st cycle

THEMATIC Research Field: MODELING MULTI-AGENT INTERACTION WITH GAME THEORY AND HUMAN-LIKE STRATEGIES

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	The continuous advancement of autonomous systems, particularly in transportation and robotics, has led to increasingly complex scenarios involving simultaneous interactions among multiple autonomous agents. Examples include autonomous vehicles navigating traffic, collaborative robots in industrial environments, and drones sharing airspace. Current solutions often fall short in comprehensively addressing strategic interactions, uncertainty, and safety requirements, resulting in inefficiencies, conflicts, or unsafe conditions. This research aims to overcome these limitations by developing innovative methods grounded in advanced mathematical frameworks and modern control strategies. Specifically, it will establish theoretical foundations using game-theoretic approaches to accurately model cooperative and competitive agent interactions, not only considering autonomous vehicles, but even human driven cars. On this purpose, the behavior of a human driver will be modelled using machine learning techniques. The final goal is to deliver a comprehensive, efficient, and scalable methodological toolkit for safe and optimal multi-agent interactions among autonomous and human-driven vehicles. This toolkit will be thoroughly validated through simulations and experimental studies, including testing in advanced driving simulators, to support the practical deployment of autonomous systems.
Methods and techniques that will be	The methodological framework developed in this research

developed and used to carry out the research	The methodological framework developed in this research will merge several advanced theoretical and applied techniques into a coherent approach for multi-agent trajectory planning. Initially, differential game theory will serve as the primary tool for understanding and modelling interactions among multiple autonomous entities. To verify the robustness of the developed methodology, the interaction with human-driven vehicles will be considered. Tests will be carried out both using driving simulators or by developing human-like driver models through machine learning approaches.Given the necessity of real-time implementation, computational efficiency will be a key consideration. To this end, numerical solvers such as ACADOS and FORCES Pro will be employed to ensure algorithms developed can run effectively on embedded hardware. The research approach will conclude with extensive validation through realistic simulation platforms to be decided: (as CARLA, IPG CarMaker, ROS/Gazebo, Vi-Grade) potentially extending to experimental robotic setups, thus demonstrating both theoretical soundness and practical applicability. Specifically, the use of driving simulators will be employed.
Educational objectives	The educational goals associated with this PhD project aim at providing a highly interdisciplinary set of skills and knowledge. The candidate will develop a deep understanding of multi-agent decision-making theories grounded in game theory, becoming proficient in predicting, modelling, and influencing complex interactive behaviours.Simultaneously, the candidate will acquire expertise in robust and stochastic optimization, which are crucial for handling uncertainties prevalent in practical scenarios involving autonomous systems. Beyond theoretical knowledge, the candidate will gain substantial hands-on experience with advanced computational techniques and real-time embedded control system implementation on driving simulators and prototype vehicles. Furthermore, the candidate will regularly engage in scientific communication and dissemination activities, such as writing scientific papers and presenting at international conferences, thus fostering essential professional and academic communication skills.

Job opportunities	Upon completion of this PhD program, candidates will be well-equipped for advanced professional roles across academia, industry, and governmental bodies. Graduates will find suitable opportunities in academic and research institutions as researchers specializing in control systems, robotics, or autonomous vehicles.In industry, potential employment sectors include the automotive and aerospace industries, companies developing robotics and automation technologies. Due to their expertise in formal safety verification and multi-agent system management, graduates will also be valuable to regulatory agencies and institutions responsible for standardizing and certifying safety-critical autonomous technologies.In summary, the diverse skill set, and specialized knowledge obtained through this doctoral program will significantly enhance employability, providing multiple career paths with considerable opportunities for growth, leadership, and innovation.
Composition of the research group	2 Full Professors 2 Associated Professors 0 Assistant Professors 2 PhD Students
Name of the research directors	Proff. F.Braghin,S.Arrigoni, E.Sabbioni, S.Melzi

Contacts
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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents	--

Scholarship Increase for a period abroad	
Amount monthly	750.0 €
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 €6,114.50.
PhD candidates benefiting from this scholarship are required to spend a research period of at least 3 months abroad, joining high-level research groups in their specific research field, as agreed upon with their Supervisor. An increase in the scholarship will be applied for periods up to 6 months (approximately €750/month – net amount). Additionally, candidates who spend at least 3 months abroad are eligible for an extra reimbursement of €3.000 to cover travel expenses.
Teaching assistantship: availability of funding in recognition of supporting teaching activities by the PhD candidate. There are various forms of financial aid for activities related to teaching support. The PhD student is encouraged to take part in these activities, within the limits allowed by the regulations.