

MATHEMATICAL SCIENCES

DISMA - Optimal fleet management of autonomous mobile robots for intralogistics applications

Funded By	Dipartimento DISMA
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Context of the research activity	Efficient warehouse management and material handling are key requirements to support both manufacturing and e-commerce activities. Traditionally, Automated Guided Vehicles (AGVs) were used in manufacturing, and human pickers were in charge of e-commerce warehouses. Autonomous Mobile Robots (AMRs) are replacing AGVs, offering a more flexible form of automation, able to adapt to changing demand patterns and able to interact with human pickers. The PhD is framed within an industrial project aimed at developing a library of optimization methods to schedule material handling and route AMRs in an efficient manner.
	Efficient warehouse management and material handling are key requirements to support both manufacturing and e-commerce activities. In the former case, materials must be picked from inventory and brought to the shop floor, at the right place and at the right time, in order to synchronize assembly and meet customer order due dates. The latter case is more and more relevant in the light of the increase in e-commerce traffic. Traditionally, automated guided vehicles (AGVs) were used in manufacturing, and human pickers were in charge of e-commerce warehouses. Autonomous mobile robots are replacing AGVs, offering a more flexible form of automation, able to adapt to changing demand patterns and interact with human pickers when needed. The aim of the PhD is to investigate and extend optimization methods to schedule the activities of a fleet of AMRs, which must be routed in an efficient manner, avoiding collisions and deadlocks, ensuring safe interactions with human personnel, and taking into due account all of the relevant constraints (energy, order due dates, priorities, etc.). Depending on traffic intensity and environmental uncertainty, we may apply traditional routing methods based on combinatorial optimization, or more recent reinforcement learning strategies. There is no one-size-fits-all solution, and the project aims at devising a rich library of algorithmic modules that may be configured and integrated for different application settings. Artificial intelligence tools may

Objectives	support the selection and configuration process. The references listed below provide some clues about the possible concepts behind the development of the algorithmic modules. It is important to stress that this is a project where sophisticated optimization methods are framed within a real life setting. In fact, the PhD position is partially funded by the OMERO industrial research project within the SWIch framework of the Piedmont region, whose aim is to foster technological innovation. The OMERO acronym stands for: Optimization of autonoMous mobilE Robots. Besides the Department of Mathematical Sciences of Politecnico di Torino, industrial partners of the project are Spindox (https://makeamark.spindox.it/) and RoboMove (https://robomove.it/). An integral part of the project is to interface the algorithmic tools with simulation modules in order to validate the chosen architecture (type and number of AMRs, layout, etc.) and evaluate its performance, as well as to devise operational software connecting with a factory or warehouse information system, like an ERP (Enterprise resource Planning) or MES (Manufacturing Execution System) tools. References: • R. Allgor, T. Cezik, D. Chen (2023). Algorithm for robotic picking in Amazon fulfillment centers enables humans and robots to work together effectively. <i>INFORMS Journal on Applied Analytics</i> 53:266-282 • M. Battistotti, P. Brandimarte, F. Giancola, N. Mazzi (2025). Scheduling autonomous robots for an intralogistic application: A comparison of lookahead-based ADP strategies. <i>Expert Systems with Applications</i> 271:126590 • N. Boysen, S. Schwerdfeger, M.W. Ulmer (2023). Robotized sorting systems: Large-scale scheduling under real-time conditions with limited lookahead. <i>European Journal of Operational Research</i> 10:582-596 • M. Löffler, N. Boysen, M. Schneider (2023). Human-robot cooperation: Coordinating autonomous mobile robots and human order pickers. <i>Transportation Science</i> 57:979-998 • L. Zhen, Z. Tan, R. de Koster, X. He, S. Wang, H. Wang (2025). Optimizing warehouse operations with autonomous mobile robots. <i>Transportation Science</i> 59:1130-1152
Skills and competencies for the development of the activity	• Background knowledge in combinatorial optimization methods like metaheuristics and matheuristics (e.g., vehicle routing, network design, machine scheduling). • Background knowledge in reinforcement learning. • Suitable programming skills, including object-oriented design (e.g., in Python).