BORSA N. 26

DAUSY

D.M. 352/2022

Co-finanziata da: ICAM S.r.l.
Tematica: “Decision and control techniques for fleets of cooperative robots in automated warehouses”

**Research theme title:**

Decision and control techniques for fleets of cooperative robots in automated warehouses

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**Curriculum of DAUSY:**

C1 AS for Automation

**Hosting University/Research Centre**

Polytechnic of Bari

**Department:**

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**Prospective Supervisors:**

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Description:

In the Industry 4.0 paradigm, which aims at establishing intelligent, interoperable, and autonomous production environments, the problem of planning, management, and control fleets of Automated Guided Vehicles (AGVs) and/or Rail Guided Vehicles (RGVs) is receiving enormous interest for an efficient and sustainable logistics. Traffic management of cooperating robots for handling loads in automated warehouses of smart factories and distribution centers is indeed a significant challenge for the real-time control aimed at predicting and preventing congestion while ensuring an increase in productivity and business flexibility.

The goal of this project is to improve the performance of automated warehouses by developing scheduling algorithms for the activities carried out by the multi-robot system, together with path-planning, collision avoidance, driving, navigation, and control algorithms. In particular, conventional task allocation and path planning algorithms will be merged into machine learning frameworks with the aim of controlling AGVs' and/or RGVs' fleets in real-time and scheduling their activities in an optimal way by collecting and managing a large amount of data obtained by several simulated and real-world industrial scenarios. Thus, the main challenges will lie in defining machine learning techniques -such as supervised learning (e.g., artificial neural networks, support vector machines), unsupervised learning (e.g., principal component analysis), reinforcement learning and deep learning (e.g., convolutional neural networks, restricted Boltzmann machine and auto-encoders)- aimed at predicting and preventing congestion in vehicular traffic. In order to improve the efficiency of AGVs and/or RGVs, maximize productivity, and minimize downtime, scheduling algorithms will be also developed based on the integration of data-driven methods with simulation, optimization, and optimal control techniques.

The research will be applied to real logistic scenarios provided by ICAM Srl, which is an Italian company specialized in automated solutions for automated warehousing and Logistics 4.0.

Specific Information:

Applicants must hold a master's degree in Engineering, with a good background in relevant areas of interest (i.e., machine learning, optimization, and control). Solid mathematical and coding skills are encouraged. Proficiency in both spoken and written English is required. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving both theoretical analysis and experimental validation, in strong connection with an Italian logistic company, which will be the final user of the applications. Technical and soft skills are strongly required to meet, during the research, a continuous trade-off between industrial needs and research challenges.

References:

[1]. Angelopoulos, A., Michailidis, E. T., Nomikos, N., Trakadas, P., Hatziefremidis, A., Voliotis, S., & Zahariadis, T. (2019). Tackling faults in the industry 4.0 era—a survey of machine-learning solutions and key aspects. Sensors, 20(1), 109.
[2]. Lee, S., Kim, Y., Kahng, H., Lee, S. K., Chung, S., Cheong, T., ... & Kim, S. B. (2020). Intelligent traffic control for autonomous vehicle systems based on machine learning. Expert Systems with Applications, 144, 113074.
[3]. Digani, V., Hsieh, M. A., Sabattini, L., & Secchi, C. (2019). Coordination of multiple AGVs: a quadratic optimization method. Autonomous Robots, 43(3), 539-555.

[4]. Ferrara, A., Gebennini, E., & Grassi, A. (2014). Fleet sizing of laser guided vehicles and pallet shuttles in automated warehouses. International Journal of Production Economics, 157, 7-14.
[5]. Cardarelli, E., Digani, V., Sabattini, L., Secchi, C., & Fantuzzi, C. (2017). Cooperative cloud robotics architecture for the coordination of multi-AGV systems in industrial warehouses. Mechatronics, 45, 1-13.
[6]. Digani, V., Sabattini, L., Secchi, C., & Fantuzzi, C. (2015). Ensemble coordination approach in multi-AGV systems applied to industrial warehouses. IEEE Transactions on Automation Science and Engineering, 12(3), 922-934.
[7]. Chen, J., Zhang, X., Peng, X., Xu, D., & Peng, J. (2022). Efficient routing for multi-AGV based on optimized Ant-agent. Computers & Industrial Engineering, 167, 108042.
[8]. Niu, Y., Schulte, F., & Negenborn, R. R. (2021). Human Aspects in Collaborative Order Picking–Letting Robotic Agents Learn About Human Discomfort. Procedia Computer Science, 180, 877-886.

## Type of scholarship:

DM 352/2022 – Industrial Project

## Study and research period outside the Hosting Institution:

11. Study and research period at the company:
- period length: 12 months;
- Company:
  - ICAM srl
  - S.P. 237 delle Grotte, Putignano BA 70017 Italy
  - https://www.icamonline.eu/en/

12. Study and research period abroad:
- period length: 6 months;
- Hosting institution:
  - Delft University of Technology - Department of Maritime and Transport
  - Leeghwaterstraat 17 2628 CA Delft – The Netherlands
  - http://www.negenborn.net/ -- http://www.mtt.tudelft.nl/