I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Industry 4.0

Research themes

For larger companies, robotics has been a key productivity factor for many years; nowadays, thanks to the development of the new enabling technologies of Industry 4.0, such as collaborative robotics and artificial intelligence, robotics is also becoming increasingly relevant for smaller industries, which are crucial for Italy's production and employment capacity. Many drivers are pushing the adoption of robotic technology in industry, such as the need of products customisation, the increase in competitiveness in the global market and the progressive penetration of cobots in human-centred manufacturing scenarios.

The introduction and spread of the Industry 4.0 production paradigm has given more boost to the use of robots, since they are interconnected, highly digitised autonomous agents,

equipped with a digital twin, able to improve their performance based on the analysis of data collected in production systems. On the other hand, as also highlighted by the European Economic and Social Committee (EESC), the next transition to Industry 5.0 will be characterised by the shift from coexistence to full cooperation, physical and social, between machines and people.

All these topics are addressed with an integrated and multidisciplinary approach by the projects proposed in this curriculum; they represent cutting-edge technological challenges that can certainly be tackled due to the scientific and technological background of the proposing institutions and the experience of the involved researchers. The main objectives of the 15 proposed research themes are:

- Optimisation of production processes based on human-machine collaboration, with real-time adaptation of collaborative robots to human dynamic factors and intentions (themes 1, 3, 6, 13)
- Ability of the industrial robot to interact with unstructured environments and learn the correct execution of a task, using machine learning and artificial intelligence techniques (themes 4, 11)
- New tools and operational paradigms enabling risk assessment in collaborative operations and safe operation in mixed human-robot environments, with development of new sensors for reliable perception of human presence (themes 7, 12)
- Fleet management of AGVs and AMRs for logistics and inspection, exploiting advanced and intelligent integration with corporate MES (themes 1, 4, 5, 8, 9)
- Development of software and hardware solutions for collaborative mobile robotics, thus extending the workspace of the manipulators and their field of application at large (themes 3, 7, 8)
- Development of smart tools and end-effectors, e.g. for dexterous manipulation, exploiting the innovations of material science and in the mechatronics field (themes 10, 11, 14)
- The robot is a cyber-physical system strictly linked to its digital representation: the availability of digital twins will enable new developments in predictive maintenance, production monitoring and performance optimisation (themes 2, 6)
- New robotic methodologies and equipment will make the industrial processes more sustainable, especially in terms of production costs and energy consumption: (theme 15)

The main goals of the Industry 4.0 curriculum are:

- Encourage technology transfer from research to industry, particularly in the industrial sectors that can best exploit the use of robotics.
- Give industry the opportunity to help direct the research of PhD students, as demonstrated by the high number of scholarships in the curriculum funded or co-funded by companies
- Give PhD students the opportunity to spend some time within the companies participating in the training project

The ideal candidates are students with a Master (or equivalent/higher) degree in STEM field: a specific background in Robotics or mechatronics will be appreciated.

The students will perform their research project at the hosting institution (as described in the research project sheet). Interested applicants are encouraged to contact the tutors and/or the Unit's Principal Investigators for clarifications before submitting their application.

International applications are encouraged and applicants will receive logistic support with visa issues, relocation, etc.

1. Mechatronic Technologies for the Smart Factory - Intellimech & Univ. Pisa

Curriculum: Industry 4.0

Hosting Institution
Consorzio Intellimech and Università di Pisa

Department:
Dipartimento di Ingegneria dell'Informazione

Tutor(s):
Antonio Bicchi, Manuel Catalano, Stefano Ierace

Description:
The arrival of the Industry 4.0 scenario requires more and more integration of technologies, from digital to robotics, from IoT to Communication, from AI to Machine Learning. Sometimes the 4.0 paradigm fails due to the fact that the technology should always be associated to value-generation for a company. Stemming from this consideration, the Research theme aims at evaluating, in particular in robotics and Human Robotic collaboration paradigm, industrial scenarios of the usage of robotics (mainly soft robotics) in a smart factory. More in detail, possible area of investigation could be (as an example but not binding):

- Autonomous Mobile Robots for Logistics 4.0
- Application of "metaverso" technologies for plant simulation and digitalization
- Technologies for Human Robot Collaboration

In particular, the research will be applied in a real industrial scenario provided by Intellimech which is a consortium of 44 enterprises located in Kilometro Rosso Innovation District, one of the most prestigious research area in Italy and totally privately owned.

Requirements:
Applicants are expected to carry out their research in a TRL6/7, in strong connection with industry belonging to Intellimech Consortium which will be the final user of the applications. Technical and soft skills are strongly required since, during the research, a continuous information exchange between industrial needs and research topics will be addressed in order to reach the goal of a market innovation usable in a real industrial context.

References:

- G. Lentini, G. Grioli, M. G. Catalano and A. Bicchi, "Robot Programming without Coding," 2020 IEEE International Conference on Robotics and Automation (ICRA), 2020, pp. 7576-7582, doi: 10.1109/ICRA40945.2020.9196904.
- Ajoudani, Arash, et al. "Progress and prospects of the human–robot collaboration." Autonomous Robots 42.5 (2018): 957-975.
- M. Simonič et al., "Modular ROS-based software architecture for reconfigurable, Industry 4.0 compatible robotic workcells," 2021 20th International Conference on Advanced Robotics (ICAR), 2021, pp. 44-51, doi: 10.1109/ICAR53236.2021.9659378.
- M. Garabini et al., "WRAPP-up: A Dual-Arm Robot for Intralogistics," in IEEE Robotics & Automation Magazine, vol. 28, no. 3, pp. 50-66, Sept. 2021, doi: 10.1109/MRA.2020.3015899.
- Pardi, T. et al. (2020). A Soft Robotics Approach to Autonomous Warehouse Picking. In: Causo, A., Durham, J., Hauser, K., Okada, K., Rodriguez, A. (eds) Advances on Robotic Item

Picking. Springer, Cham. https://doi.org/10.1007/978-3-030-35679-8_3

Company name and link (for industrial projects):
Consorzio Intellimech (https://www.intellimech.it/)

Number of positions available:

1

Main Research Site
Kilometro Rosso Innovation District, Via Stezzano 87, 24126 Bergamo, Italy

Contacts:
Email: Antonio.bicchi@ing.unipi.it, Manuel.catalano@gmail.com, stefano.ierace@intellimech.it

Funding Scheme: These industrial doctorate grants are co-funded by the proponent research institution, company and by the Italian Ministry of Research, under law D.M. 352/2022.

2. Mechatronic Technologies for Intelligent Machines - Intellimech & Univ. Pisa

Curriculum: Industry 4.0

Hosting Institution
Consorzio Intellimech and Università di Pisa

Department:
Dipartimento di Ingegneria dell'Informazione

Tutor(s):
Antonio Bicchi, Manuel Catalano, Stefano Ierace

Description:
Mechatronics technologies are strongly increasing in the last years, due to the developments in technologies such as robotics, Artificial Intelligence, Digital. On the other side, sometimes industries fail to find an "evolution path" to transfer and adopt these innovative technologies on their product, in particular in the machinery field which is conservative and in which industries need to test and evaluate an application before the adoption. In this scenario, the Research Theme aims at focusing on the usage of mainly robotics R&D technologies to apply in a real industrial scenario provided by Intellimech which is a consortium of 44 enterprises located in Kilometro Rosso Innovation District, one of the most prestigious research area in Italy and totally privately owned. More in detail, the Theme will be around the implementation of technologies such as (as examples but not binding):

- robot avatar for maintenance and technical support in machines service envinronment
- robots "meta"-operated
- application of "metaverso" technologies for machines modelling and simulations
- …

Requirements:
Applicants are expected to carry out their research in a TRL6/7, in strong connection with industry belonging to Intellimech Consortium which will be the final user of the applications. Technical and soft skills are strongly required since, during the research, a continuous information exchange between industrial needs and research topics will be addressed in order to reach the goal of a market innovation usable in a real industrial context.

References:

- G. Lentini et al., "Alter-Ego: A Mobile Robot With a Functionally Anthropomorphic Upper Body Designed for Physical Interaction," in IEEE Robotics & Automation Magazine, vol. 26, no. 4, pp. 94-107, Dec. 2019, doi: 10.1109/MRA.2019.2943846.
- S. Fani et al., "Simplifying Telerobotics: Wearability and Teleimpedance Improves Human-Robot Interactions in Teleoperation," in IEEE Robotics & Automation Magazine, vol. 25, no. 1, pp. 77-88, March 2018, doi: 10.1109/MRA.2017.2741579.
- F. Negrello et al., "Humanoids at Work: The WALK-MAN Robot in a Postearthquake Scenario," in IEEE Robotics & Automation Magazine, vol. 25, no. 3, pp. 8-22, Sept. 2018, doi: 10.1109/MRA.2017.2788801.
- Grioli G, Wolf S, Garabini M, et al. Variable stiffness actuators: The user's point of view. The International Journal of Robotics Research. 2015;34(6):727-743.

doi:10.1177/0278364914566515
- M. Bonilla et al., "Grasping with Soft Hands," 2014 IEEE-RAS International Conference on Humanoid Robots, 2014, pp. 581-587, doi: 10.1109/HUMANOIDS.2014.7041421.
- F. Angelini, C. Petrocelli, M. G. Catalano, M. Garabini, G. Grioli and A. Bicchi, "SoftHandler: An Integrated Soft Robotic System for Handling Heterogeneous Objects," in IEEE Robotics & Automation Magazine, vol. 27, no. 3, pp. 55-72, Sept. 2020, doi: 10.1109/MRA.2019.2955952.
- C. Gabellieri et al., "Grasp It Like a Pro: Grasp of Unknown Objects With Robotic Hands Based on Skilled Human Expertise," in IEEE Robotics and Automation Letters, vol. 5, no. 2, pp. 2808-2815, April 2020, doi: 10.1109/LRA.2020.2974391.

Company name and link (for industrial projects):
Consorzio Intellimech (https://www.intellimech.it/)

Number of positions available:

1

Main Research Site
Kilometro Rosso Innovation District, Via Stezzano 87, 24126 Bergamo, Italy
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Funding Scheme: These industrial doctorate grants are co-funded by the proponent research institution, company and by the Italian Ministry of Research, under law D.M. 352/2022.

3. Advanced Human-Robot Interaction and Collaboration – Italian Institute of Technology & Univ. Pisa

Curriculum: Industry 4.0

Hosting Institution
Istituto Italiano di Tecnologia and Università di Pisa

Department:
Human-Robot Interfaces and physical Interaction

Tutor(s):
Dr. Arash Ajoudani and Prof. Antonio Bicchi

Requirements:
The successful candidate must have an MSc degree with a strong background in Robotics, Teleoperation, and/or physical human-robot interaction.
The successful candidate should have:

- Good skills on C++ and Python
- Experience with ROS
- Confidence with version control tools (specifically git)
- Good communication skills and ability/willingness to integrate within a multidisciplinary international research group
- Good knowledge of written and spoken English.

References:

- Kim, Wansoo, et al. "A human-robot collaboration framework for improving ergonomics during dexterous operation of power tools." Robotics and Computer-Integrated Manufacturing 68 (2021): 102084.
- Kim, Wansoo, et al. "Adaptable workstations for human-robot collaboration: A reconfigurable framework for improving worker ergonomics and productivity." IEEE Robotics & Automation Magazine 26.3 (2019): 14-26.

Company name and link (for industrial projects):

This PhD theme will be in collaboration with the IIT-Intellimech joint lab: https://www.joiintlab.com/

Number of positions available:

1

Main Research Site
Center for Robotics and Intelligent Systems, Italian Institute of Technology
Via San Quirico 19D, 16163

Contacts:
Email: Arash@Ajoudani@iit.it

Funding Scheme: These industrial doctorate grants are co-funded by the proponent research institution, company and by the Italian Ministry of Research, under law D.M. 352/2022

4. Swarms of Heterogeneous Soft Robots - National Research Council - ISTC

Curriculum: Industry 4.0

Hosting Institution
Consiglio Nazionale delle Ricerche

Department:
Istituto di Scienze e Tecnologie della Cognizione

Tutor(s):
Vito Trianni, Andrea Orlandini

Description:
Swarm robotics deals with the design of decentralized robotic systems composed of relatively simple individuals, whereby complexity at the group level results from self-organization and communication among the robots. Classic approaches to the design of such systems rely on homogeneous groups of conventional electromechanical robots, which are designed exploiting design patterns or automatic design methods. To move beyond these studies, the proposed research wants to remove these conventional assumptions to study, on the one hand, the effects of heterogeneity in the dynamics of robot swarms, and on the other hand, the possibilities and constraints offered by soft-bodied robots that open new ways of interaction through soft physical contacts and self-assembly. The research will open the way to a new generation of self-assembly robotic systems, proposing novel design principles and methods that will improve swarm robotics in terms of flexibility, expansibility, agility and re-configurability onto new and exciting grounds.

Requirements:
Applicants are expected to study heterogeneous soft robotic swarms with a mix of simulations and real robot experimentation. The goal is to investigate new design methods to provide a robot swarm with collective sensing and reasoning abilities, making the group capable of climbing a noisy gradient that individual robots cannot reliably perceive. The project starts with Kilobot robots, addressing the design of minimalistic heterogeneous control strategies leading the Kilobots to climb a virtual gradient. The implementation will explore the use of semantic tools to support both manual and automatic design methods, while experiments will be conducted both in simulation and with physical robots. Second, the soft robotics aspects will be considered, adapting simple simulations of soft robots to enable interaction and self-assembly in different contexts. The goal is to test different ways of performing collective sensing and reasoning, as a result of heterogeneity and soft interactions. Also in this case, both manual and automatic design methods will be considered.

References:

- Adaptive Strategies for Team Formation in Minimalist Robot Swarms *Luigi Feola, Vito Trianni.* IEEE Robotics and Automation Letters 2021
  https://dx.doi.org/10.1109/lra.2022.3150479
- Swarm Robotics: Past, Present, and Future *Marco Dorigo, Guy Theraulaz, Vito Trianni.*
  Proceedings of the IEEE 2021
  https://dx.doi.org/10.1109/jproc.2021.3072740
- Reflections on the future of swarm robotics *Marco Dorigo, Guy Theraulaz, Vito Trianni*.
  Science Robotics 2020

https://dx.doi.org/10.1126/scirobotics.abe4385
- Knowledge-based adaptive agents for manufacturing domains *Stefano Borgo, Amedeo Cesta, Andrea Orlandini, Alessandro Umbrico*. Engineering with Computers 2019. 35 (3), 755-779. 202. https://doi.org/10.1007/s00366-018-0630-6
- Knowledge based modules for adaptive distributed control systems *Andrea Ballarino, Alessandro Brusaferri, Amedeo Cesta, Guido Chizzoli, Ivan Cribario Bertolotti, Luca Durante, Andrea Orlandini, Riccardo Rasconi, Stefano Spinelli, Adriano Valenzano*. Factories of the Future, 83-108. Springer 2019.

Number of positions available:

1

Main Research Site
Via San Martino della Battaglia 44, 00185 Roma

Contacts:
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Funding Scheme: This doctorate grant is fully funded by the proponent research institution

5. Planning and coordination of collaborative robot teams for manufacturing applications - National Research Council – STIIMA

Curriculum: Industry 4.0

Hosting Institution
Consiglio Nazionale delle Ricerche

Department:
Istituto di Sistemi e Tecnologie Industriali Intelligenti per il Manifatturiero Avanzato (STIIMA)

Tutor(s):
Nicola Pedrocchi

Description:

The PhD candidate will work at the intersection of task planning, motion planning, and control to study how to make teams of heterogeneous robots autonomous. Research on the tight coordination of heterogeneous industrial robots is still at its infancy because it is difficult to match rich task specification, typical of assembly, and complex robot capabilities. Moreover, the variability owed to the presence of humans in shopfloors requires the robot to be flexible with respect to partially unstructured environments. The PhD candidate will develop new approaches to make robots context-aware and easily re-configurable. The candidate will combine task planning, motion planning, and control tools to develop a new distributed approach to the control of teams of heterogeneous agents.
The candidate will integrate and validate the novel methodology in a manufacturing scenario, in which a team composed of mobile robots, mobile manipulators, and fixed manipulators shall cooperate with humans in unpacking end-of-life lithium batteries in a dedicated pilot cell.

Requirements:
The PhD candidate must hold a master's degree in Engineering, Computer Science, or Applied Mathematics, with a solid background in (at least one of) the relevant areas of interest, i.e., AI, Robotics and Control. The candidate should be highly motivated and interested in undertaking innovative and challenging research activities involving the theoretical analysis and experimental validation. Excellent mathematical and coding skills (C++/Python, ROS) are encouraged. Proficiency in both spoken and written English is required. Knowledge of the Italian language is not required.

References:

- S. Pellegrinelli, A. Orlandini, N. Pedrocchi, A. Umbrico, T. Tolio. Motion planning and scheduling for human and industrial-robot collaboration. CIRP Annals, Volume 66, Issue 1, 2017, Pages 1-4.
- S. Mutti, G. Nicola, M. Beschi, N. Pedrocchi, L. Molinari Tosatti. Towards optimal task positioning in multi-robot cells, using nested meta-heuristic swarm algorithms. Robotics and Computer-Integrated Manufacturing, Volume 71, 2021, 102131.
- T. Babu Pulikottil, S. Pellegrinelli, N. Pedrocchi. A software tool for human-robot shared-workspace collaboration with task precedence constraints. Robotics and Computer-Integrated Manufacturing, Volume 67, 2021, 102051.

- M. Faroni, M. Beschi, N. Pedrocchi and A. Visioli. Predictive inverse Kinematics for redundant manipulators with task scaling and kinematic constraints. IEEE Transactions on Robotics, Volume. 35, Issue 1, 2019, pp. 278-285.
- P. Franceschi, N. Castaman, S. Ghidoni and N. Pedrocchi. Precise Robotic Manipulation of Bulky Components. IEEE Access, Volume 8, 2020, pp. 222476-222485.

Number of positions available:

1

Main Research Site
CNR-STIIMA
Via Alfonso Corti 12, 20133 Milano, Italy

Contacts:
Email: Nicola.pedrocchi@stiima.cnr.it

Funding Scheme: This doctorate grant is fully funded by the proponent research institution

6. Intelligent Machines for small batch production - National Research Council – STIIMA

Curriculum: Industry 4.0

Hosting Institution
Consiglio Nazionale delle Ricerche

Department:
Istituto Sistemi e Tecnologie Industriali Intelligenti per il Manufatturiero Avanzato (STIIMA)

Tutor(s):
Giacomo Bianchi; Marco Leonesio

Description:
Intelligent Machines are able to extend, via machine learning techniques producing hybrid models, pre-existing knowledge founded on physic-based first principles and technologist experience. For this purpose, production machines must be integrated in the factory information system and equipped with interconnected sensors and local processing ability.
Industrial production, nowadays, must cope with a significant market uncertainty and increasing product customization, to satisfy high value market niches. Manufacturing systems must therefore assure high efficiency also in small batch production: it is more and more important to support process optimization for new workpieces. The hybrid optimization models must learn from reduced sets of experiments and manage production in different operating conditions.
The foreseen solution relies, at one level, on off-line learning, collecting data from a fleet of Intelligent Machines and, on a second level, on real-time process monitoring and control, to alleviate the effect of modelling errors and disturbances.
The proposed PhD focuses on designing the data and Machine Learning methods to learn from the production of different workpieces, in different operating conditions, to improve model generality and accuracy. The work will analyze a specific application scenario (e.g. a grinding machine) and setup an intelligent framework where the production mission, in terms of workpiece, machine and process characteristics, is described. The framework must also collect part quality measurements and expert judgement. Specific methodologies (for instance, Interval Predictor Models) must be adopted to formally manage uncertainty and monitor incremental learning, i.e. indicating the need for additional inputs (by error and clustering analyses). The system could also suggest experiments, following the approach of sequential kriging meta-models to reduce prediction uncertainty or the physics-guided machine learning (PGML). Distributed learning, multi-agent reinforcement learning and transfer learning, as methodologies to extend model generality exploiting a fleet of machines, could be considered.

Requirements:
The PhD aims at reaching the multi-disciplinary knowledge required to develop Intelligent Machines for manufacturing. As it's expected that a graduated student does not already possess this multi-disciplinary know-how, applicants are expected to offer a mixture of knowledge and curiosity in mechanical and production engineering, signal processing, machine learning.

References:

- Chuo, Y. S., Lee, J. W., Mun, C. H., Noh, I. W., Rezvani, S., Kim, D. C., … Park, S. S. (2022). Artificial intelligence enabled smart machining and machine tools. Journal of Mechanical Science and Technology, 36(1), 1–23. https://doi.org/10.1007/s12206-021-1201-0
- Frye, M., & Schmitt, R. H. (2019). Quality improvement of milling processes using machine learning-algorithms. *16th IMEKO TC10 Conference 2019 Testing, Diagnostics and Inspection as a Comprehensive Value Chain for Quality and Safety;* 142–147
- Suya Prem Anand P., Sivakumar R., Prabadevi B. (2022). A Review on Advanced Monitoring and Identifying the Status of Grinding Machine Using Machine Learning Algorithms. *ECS Transactions*, *107*(1), 1327–1354
- Mirifar, S., Kadivar, M., & Azarhoushang, B. (2020). First steps through intelligent grinding using machine learning via integrated acoustic emission sensors. *Journal of Manufacturing and Materials Processing*, *4*(2). https://doi.org/10.3390/jmmp4020035
- Kono, H., Kamimura, A., Tomita, K., Murata, Y., & Suzuki, T. (2014). Transfer Learning Method Using Ontology for Heterogeneous Multi-agent Reinforcement Learning. International Journal of Advanced Computer Science and Applications, 5(10). https://doi.org/10.14569/ijacsa.2014.051022
- Campi, M. C., Calafiore, G., & Garatti, S. (2009). Interval predictor models: Identification and reliability. Automatica, 45(2), 382–392. https://doi.org/10.1016/j.automatica.2008.09.004.
- Huang, D., Allen, T.T., Notz, W.I. et al. Global Optimization of Stochastic Black-Box Systems via Sequential Kriging Meta-Models. J Glob Optim 34, 441–466 (2006). https://doi.org/10.1007/s10898-005-2454-3

Number of positions available:

1

Main Research Site
STIIMA-CNR Milano. Experiments will be conducted in cooperation with machine tool builders.

Contacts:
Email: Giacomo.bianchi@stiima.cnr.it

Funding Scheme: This doctorate grant is fully funded by the proponent research institution

7. New protocols and control algorithms for closer human-robot cooperation - Polytechnic University of Marche

Curriculum: Industry 4.0

Hosting Institution
Università Politecnica delle Marche

Department:
Dipartimento di Ingegneria Industriale e Scienze Matematiche

Tutor(s):
Prof. Matteo Palpacelli
Prof. Massimo Callegari

Description:

The research aims at developing methodologies and tools that on the one hand allow to assess the safety level of collaborative operations between human and robot, also in a quantitative way, and on the other hand, by exploiting the enabling technologies now available also at low cost (wearable sensors, 3D vision, artificial intelligence, virtual and augmented reality), allow a closer interaction between operator and machine and finally a higher efficiency of the production process.

The following activities will be carried out:

- Review of applicable norms and available scientific literature and development of guidelines to verify the safety of robots and collaborative systems; the opportunity to develop specific safety standards for single application fields will be studied and tested on specific robotics systems, exploiting the wide techological range of equipment available at the Laboratory i-LABS (Jesi, I). The emerging field of collaborative mobile robots will be taken into consideration too, since there is an urgent need of studies and procedures for this case. This activity will lead to the definition of indices for evaluating robot safety and could bring useful results for the definition of harmonized standards on the matter, which are currently on progress. In the end methods, procedures and tools will be proposed to support the design and verification of safety in human-robot interaction in the shared workspace.

- Development of reactive control algorithms that are able to avoid contact between the operator and the robot in a dynamic way with respect to fixed and mobile obstacles: the control software will be able to re-plan in real time trajectories that avoid contact between the robot and any obstacles present in the work area, whether fixed or mobile, respecting the safety requirements typical of collaborative robotic applications. Schemes allowing the use of multiple types of sensor information will be developed, and the possibility of introducing models of human operator behaviour will also be considered.

- Several case studies for various types of collaborative robots, fixed or mounted on mobile robots, will be examined and the effectiveness of the solutions devised will be tested through laboratory experimentation. This will be done first in compliance with the technical safety regulations, e.g. ISO/TS 15066 of 2016, and then the possibility of maintaining the required safety levels through innovative qualification procedures will

also be verified. The tests for the validation of the algorithms will be developed at the i-LABS Laboratory in Jesi, where the presence of other companies will allow validation in an industrially relevant environment (TRL 5).

Requirements:
Applicants are expected to have basic knowledge of kinematics and dynamics of mechanical systems, control, motion planning and human factors in production systems; moreover adequate skills in modeling and simulation of mechatronic equipment will be appreciated.
The candidates are expected to have attitude to problem solving and experimental work and be strongly motivated for team working.

References:

- F. Vicentini: "Collaborative Robotics: A Survey", *ASME J. Mechanical Design*, 2021, 143(4)
- C. Scoccia, G. Palmieri, M.C. Palpacelli, M. Callegari: "A collision avoidance strategy for redundant manipulators in dynamically variable environments: On-line perturbations of off-line generated trajectories", *Machines*, 2021, 9(2), 30.
- G. Chiriatti, G. Palmieri, C. Scoccia, M.C. Palpacelli, M. Callegari: "Adaptive Obstacle Avoidance for a Class of Collaborative Robots", *Machines*, 2021, 9(6), 113.
- C. Scoccia, M. Ciccarelli, G. Palmieri, M. Callegari: "Design of a human-robot collaborative system: methodology and case study", *Proc. 17th IEEE/ASME International Conference on Mechatronic and Embedded Systems and Applications*, Aug 17-19, 2021
- Gasparetto, A.; Boscariol, P.; Lanzutti, A.; Vidoni, R. Path planning and trajectory planning algorithms: A general overview. In *Motion and Operation Planning of Robotic Systems*; Springer, 2015; pp. 3–27.
- Zlajpah, L.; Nemec, B. Kinematic control algorithms for on-line obstacle avoidance for redundant manipulators. In *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems*, Lausanne, Switzerland, 30 Sept.–4 Oct. 2002; 1898–1903.

Company name and link (for industrial projects):

NA

Number of positions available:

1

Main Research Site
Dipartimento di Ingegneria Industriale e Scienze Matematiche, Ancona (I). Experiments will be conducted also at the premises of the i-LABS Laboratory in Jesi (I).

Contacts:

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Funding Scheme: This doctorate grant is co-funded by the proponent research institution and by the Italian Ministry of Research, under law D.M. 351/2022 (PNRR).

8. Cooperative and collaborative control for mobile manipulators – Univ. Basilicata

Curriculum: Industry 4.0

Hosting Institution
Università degli Studi della Basilicata

Department:
Scuola di Ingegneria

Tutor(s):
Prof. Francesco Pierri
Prof. Fabrizio Caccavale

Description:
The adoption of mobile robots in industry can contribute to improve flexibility and adaptability of production and logistic systems, especially if employed in multi-robot cooperative systems. However, this technology cannot be considered mature yet, and thus its adoption calls for innovative approaches related to robotic systems composed of multiple mobile manipulators, capable of performing industrially relevant tasks even in a collaborative way (i.e., involving the human operator in the task execution). In detail, mobile manipulators must be capable of performing cooperative manipulation tasks (e.g., transportation of large/heavy parts on the shop floor or assembly tasks) in collaboration with humans, in order to exploit the superior cognitive capabilities of humans to tackle unexpected situations and/or help to execute complex manipulation tasks. However, interaction with multiple robots becomes even more complex for humans, as the behavior of the robotic system becomes less explainable and predictable. Therefore, a fundamental change of paradigm has to be pursued: from human-to-robot unidirectional information flow to human-robot bidirectional communication, where the robot provides appropriate information on its current state and planned actions to the human operator.
Thus, the research objectives are:

- Development of novel approaches to the control of cooperative robotic systems composed by multiple mobile manipulators, based on advanced estimation/perception capabilities (e.g., visual object detection and estimation of its geometric features, payload parameters), as well as on novel distributed control (to maximize flexibility and adaptability) and diagnosis (to improve safety and predictability) methods.
- Development of novel approaches to collaboration between humans and multi-robot systems via bidirectional communication and interaction, that enable continuous human-robot communication and ergonomic task adaptation during both physical and cognitive interaction.
- Experimental demonstration of the developed methods in industrially relevant use cases.

Requirements:
Applicants are expected to have adequate skills in systems and control theory, modeling and identification of mechanical systems, robot motion planning and control, as well as basic knowledge of production systems engineering and human factor in production systems. Furthermore, good attitude for experimental work is required. The candidates are expected to have attitude to problem solving and be strongly motivated for team

working.

References:

- F. Pierri, M. Nigro, G. Muscio, F. Caccavale, “Cooperative Manipulation of an Unknown Object via Omnidirectional Unmanned Aerial Vehicles”, *Journal of Intelligent & Robotic Systems*, 100(3):1635-1649, 2020.
- F. Caccavale, P. Chiacchio, A. Marino, L. Villani, “Six-dof impedance control of dual-arm cooperative manipulators”, *IEEE/ASME Transactions on Mechatronics*, 13(5):576-586, 2008.
- G. Antonelli, F. Arrichiello, F. Caccavale, A. Marino. “Decentralized time-varying formation control for multi-robot systems”, *The International Journal of Robotics Research*, 33:1029-1043, 2014.
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- A. Marino, F. Pierri, “A two stage approach for distributed cooperative manipulation of an unknown object without explicit communication and unknown number of robots”, *Robotics and Autonomous Systems*, 103:122-133,2018.
- M. Logothetis et al., “Decentralized Impedance Control of Mobile Robotic Manipulators for Collaborative Object Handling with a Human Operator”, *29th MED*, 741-746, 2021.
- P. B. g. Dohmann and S. Hirche, “Distributed Control for Cooperative Manipulation With Event-Triggered Communication”, *IEEE Transactions on Robotics*, 36(4):1038-1052, 2020.

Company name and link (for industrial projects):

NA

Number of positions available:

1

Main Research Site
Scuola di Ingegneria, Università degli Studi della Basilicata, via dell’Ateneo Lucano 10, 85100, Potenza (PZ)

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Funding Scheme: This doctorate grant is fully funded by the proponent research institution.

9. Learning and Control Methods for Autonomous Robots in Complex Industrial Scenarios – Univ. of Bologna

Curriculum: Industry 4.0

Hosting Institution
University of Bologna

Department:
Department of Electrical, Electronic and Information Engineering "Guglielmo Marconi" (DEI)

Tutor(s):
Gianluca Palli, Giuseppe Notarstefano, Lorenzo Marconi, Claudio Melchiorri, Marco Carricato, Rocco Vertechy

Description:
The research activity proposed for this PhD position aims to develop methodological approaches and numerical toolboxes for the control of autonomous robots in the industrial environment that combine model-based control methods with "data-driven" artificial intelligence tools. The goal of these approaches will be to guide one or more autonomous robots, possibly heterogeneous, which interact with uncertain environments (possibly in the presence of obstacles) for the transport or manipulation of objects that are difficult to model. In such systems, uncertainty about the state of the environment and limited measurements require autonomous robots to learn and optimize their behavior based on experience. In particular, they will have to learn how the environment or objects are modified by the actions performed and how they can influence future actions. The designed control and machine learning laws must also guarantee the safety of operations and compliance with appropriate constraints, including time constraints. Cooperative scenarios will also be studied in which the interaction between robots can help improve learning. Typical industrial applications concern the transport and cooperative assembly, possibly with human-robot interactions, or the manipulation of deformable objects using fixed or mobile robotic platforms.

Requirements:
Applicants are expected to have knowledge in the field of robotic systems such as manipulators and AGVs, the ROS environment, design and implementation of model-based and data-driven algorithms, deep and reinforcement learning.

References:

- Khalifa, A., Palli, G. New model-based manipulation technique for reshaping deformable linear objects. Int J Adv Manuf Technol 118, 3575–3583 (2022).
- Razmjooei, H., Shafiei, M.H., Palli, G. et al. Non-linear Finite-Time Tracking Control of Uncertain Robotic Manipulators Using Time-Varying Disturbance Observer-Based Sliding Mode Method. J Intell Robot Syst 104, 36 (2022).
- R. Meattini, D. Chiaravalli, L. Biagiotti, G. Palli and C. Melchiorri, "Combining Unsupervised Muscle Co-Contraction Estimation With Bio-Feedback Allows Augmented Kinesthetic Teaching," in IEEE Robotics and Automation Letters, vol. 6, no. 4, pp. 6180-6187, Oct. 2021.
- De Gregorio, D., Zanella, R., Palli, G., Pirozzi, S., Melchiorri, C., “Integration of Robotic Vision and Tactile Sensing for Wire-Terminal Insertion Tasks”, IEEE Transactions on Automation Science and Engineering, 16(2), Page(s) 585-598, 2019.
- De Gregorio, D., Tonioni, A., Palli, G., Di Stefano, L., “Semiautomatic Labeling for Deep

Learning in Robotics” , IEEE Transactions on Automation Science and Engineering, Volume: 17(2), pp. 611-620, DOI: 10.1109/TASE.2019.2938316, 2020.
- R. Zanella and G. Palli, "Robot Learning-Based Pipeline for Autonomous Reshaping of a Deformable Linear Object in Cluttered Backgrounds," in IEEE Access, vol. 9, pp. 138296-138306, 2021.
- R. Meattini, D. Chiaravalli, G. Palli and C. Melchiorri, "sEMG-Based Human-in-the-Loop Control of Elbow Assistive Robots for Physical Tasks and Muscle Strength Training," in IEEE Robotics and Automation Letters, vol. 5, no. 4, pp. 5795-5802, Oct. 2020.
- Zaccaria F., Baldassarri A., Palli G., Carricato M., “A Mobile Robotized System for Depalletizing Applications: Design and Experimentation”, IEEE Access, 9, art. no. 9465103, pp. 96682 - 96691, 2021.
- S. Chopra, G. Notarstefano, M. Rice, and M. Egerstedt. A Distributed Version of the Hungarian Method for Multirobot Assignment. IEEE Transactions on Robotics, 33(4):932-947, 2017.
- Testa, A., Camisa, A., & Notarstefano, G. (2021). ChoiRbot: A ROS 2 toolbox for cooperative robotics. IEEE Robotics and Automation Letters, 6(2), 2714-2720.
- Testa, A., & Notarstefano, G. (2021). Generalized assignment for multi-robot systems via distributed branch-and-price. IEEE Transactions on Robotics, in press.

Company name and link (for industrial projects):

NA

Number of positions available:

1

Main Research Site

- Laboratory of Robotics and Automation (LAR), Università di Bologna, Viale Risorgimento 2, 40136 Bologna
- Center for Research on Complex Automated Systems (CASY), Università di Bologna, Viale Carlo Pepoli 3/2, 40136 Bologna

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Funding Scheme: This doctorate grant is co-funded by the proponent research institution and by the Italian Ministry of Research, under law D.M. 351/2022 (PNRR)

10. Development of CAE-based tools for electronic cams optimization – Univ. Genova

Curriculum: Industry 4.0

Hosting Institution
Università di Genova

Department:
DIME – Dipartimento di Ingegneria Meccanica, Energetica, Gestionale e dei Trasporti

Tutor:
Prof. Giovanni Berselli

Description:
Development of CAD/CAE tools for the optimal design of servo-driven mechanical systems. The project of research will focus on the study of virtual prototyping methods and tools for cam systems and electronic cams for application in high performance automatic machines. The focus will be the creation of integrated simulation environments and, possibly, plug-ins for current commercial CADs.

Requirements:
Applicants are expected to be currently employees of BORGHI S.P.A Castelfranco Emilia (MO) via Cristoforo Colombo 12 CAP 41013

References:

- G. Berselli, F. Balugani, M. Pellicciari, M. Gadaleta, "Energy-optimal motions for Servo-Systems: A comparison of spline interpolants and performance indexes using a CAD-based approach," *Robotics and Computer Integrated Manufacturing*, DOI: 10.1016/j.rcim.2016.01.003, vol. 40, pp. 55–65, 2016.
- M. Pellicciari, G. Berselli, F. Balugani. "On Designing Optimal Trajectories for Servo-Actuated Mechanisms: Detailed Virtual Prototyping and Experimental Evaluation", *IEEE/ASME Transactions on Mechatronics*, DOI: 10.1109/TMECH.2014.2361759, 20(5), pp.2039-2052, 2015.

Company name and link (for industrial projects):

BORGHI S.P.A Castelfranco Emilia (MO) via Cristoforo Colombo 12 CAP 41013

Number of positions available:

1

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Email: giovanni.berselli@unige.it

Funding Scheme: This industrial doctorate grant is fully funded by companies on behalf and proponent research institution. Application is reserved to company's employees.

11. Multimodal Sensing for Robot Self-aware Control – Univ. Genova

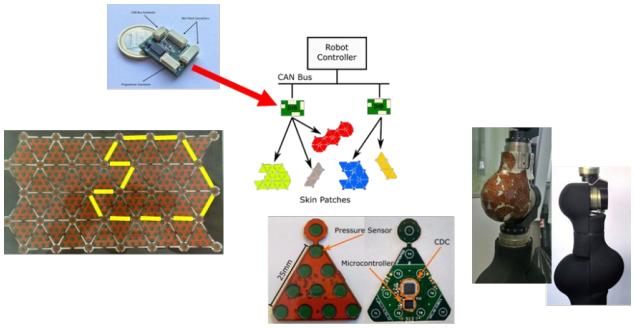
Curriculum: Industry 4.0

Hosting Institution
Università degli Studi di Genova

Department:
Department of Informatics, Bioengineering, Robotics and Systems Engineering, University of Genova

Tutor(s):
Prof. Giorgio Cannata

Description:
Robots are expected to move and interact safely with objects and humans; therefore, they require a complete perception of their surrounding space as well as the capability to physically interact with the environment and objects properly. To this aim tactile and proximity (distance) sensing are key technologies for the feedback control of robot operating in cluttered environments.



Over the years at the University of Genova [1], we have developed technologies for the implementation of large area tactile sensors (a.k.a. robot skin - see the picture, and video). The goal of this research project is to develop a new and innovative type of large area robot-skin integrating both tactile and proximity sensing modes. State-of-the-art proximity sensing chips, used on cars, smartphones and other consumer devices, will make possible to create a multimodal skin allowing the robot to obtain a complete *visuo-tactile* perception of the space around it (*skin-vision*).

Two main topics are explored in the project: (1) Electronic design of the proximity and tactile sensor networks; (2) design and implementation of a data acquisition microcontroller based network for real-time proxy-tactile data acquisition and processing.

Proxy-tactile sensors will be implemented using flexible electronic solutions, and different technologies will be explored starting from state-of-the-art flex printed circuit boards, up to printed electronic solutions. Prototypes of the sensors will be integrated on real robots and demonstrated in different industrial test cases.

This doctorate project is part of the Horizon Europe Project - Sestosenso (starting in October 2022). This research activity will be carried out together with the Research Institutes of Sweden, University of Oxford, and the company Inertia Technology.

Requirements:
Applicants are expected to have interest for electronic design, embedded system design and mechatronic design. Also the applicants are expected to have a good attitude to work on innovative problems and with ready to learn innovative technologies (e.g. additive printed electronics). The candidates must have a very good attitude for experimental activity. Finally

the candidates are expected to work within an international research team and must be strongly motivated for team working.

References:

- P. Maiolino, M. Maggiali, G. Cannata, G. Metta, L. Natale. A Flexible and robust large scale capacitive tactile system for robots. IEEE Sensors Journal, vol. 13, no. 10, pp. 3910-3917, October 2013.

Company name and link (for industrial projects):

NA

Number of positions available:

1

Main Research Site
DIBRIS – Universita' degli Studi di Genova

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Funding Scheme: This doctorate grant is co-funded by the proponent research institution and by the Italian Ministry of Research, under law D.M. 351/2022 (PA)

12. Human-Robot Interaction for Industry 4.0 and Service Robotics – Univ. Naples

Curriculum: Industry 4.0

Hosting Institution
Università degli Studi di Napoli Federico II

Department:
Department of Electrical Engineering and Information Technologies

Tutor(s):
Prof.ssa Silvia Rossi, Prof. Luigi Villani

Description:
This research theme aims at exploring the potentialities of the use of Machine Learning (ML) techniques whereas the robot learns both from observations from the environment and a secondary source, like human teacher. Collaborative robots are becoming increasingly popular in manufacturing assembly, as a way of handling the ever-increasing demands on flexibility and efficiency. In this context, ML is progressively assuming an important role for its potential applications in flexible manufacturing scenarios, whereas the proper behavior for the automation can be learn from the observation and analysis of the working environment and the positive/negative effects of the robot's actions. The same is for service robotics applications, as for example in food and drinks preparation, where ML techniques may help in solving problems linked to robot manipulation, computer vision, and human-robot-interaction. The goal is to investigate algorithms for robotic systems making them able, on the one hand to automate manufacturing processes, but on the other hand to manage these processes dynamically in interaction with humans.

Requirements:
Applicants are expected to have a master's degree or equivalent either in Robotics, Computer Science, or Engineering. Previous experience in machine learning, robot programming, and/or human-robot research is preferential.

References:

- R. Perez-Dattari, C. Celemin, G. Franzese, J. Ruiz-del-Solar and J. Kober, "Interactive Learning of Temporal Features for Control: Shaping Policies and State Representations From Human Feedback," in *IEEE Robotics & Automation Magazine*, vol. 27, no. 2, pp. 46-54, June 2020, doi: 10.1109/MRA.2020.2983649.
- S.Nikolaidis, R.Ramakrishnan, K.Gu, J.Shah, Efficient Model Learning from Joint-Action Demonstrations for Human-Robot Collaborative Tasks, ACM/IEEE International Conference on Human-Robot Interaction 2015-March (2015) 189–196. doi:10.1145/2696454.2696455.

Company name and link (for industrial projects):

Totaro s.r.l. (http://www.totaroautomazioni.it)

Number of positions available:

1

Main Research Site
PRISCA Lab, Università degli Studi di Napoli Federico II

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Funding Scheme: These industrial doctorate grants are co-funded by the proponent research institution, company and by the Italian Ministry of Research, under law D.M. 352/2022.

13. Optimization of collaborative robotic assembly tasks – Univ. Padova

Curriculum: Industry 4.0

Hosting Institution
Università degli Studi di Padova

Department:
Dipartimento di Ingegneria Industriale
Dipartimento di Ingegneria dell'Informazione

Tutor(s):
Giulio Rosati
Emanuele Menegatti

Description:
The study of optimized collaborative robotics solutions is one of the elements that can most contribute to the innovation of the production systems of companies, to increase the competitiveness of the production system and of Small and Medium Enterprises (SMEs) in particular. Collaborative robotics allows to integrate new technologies, sensors and digitalization into production processes characterized by high flexibility such as those of SMEs, in which complete automation of the production process is impractical due to complexity and costs. However, the use of collaborative robots in real industrial contexts is not always easy to implement. The aim of the doctorate project is to create advanced collaborative robotics solutions, characterized by the simplicity of integration into the company production system and interaction with the human being. The project includes 6 months abroad in top-ranking universities.

Requirements:
Applicants are expected to have very good skills in at least two of the following areas: software development, robot kinematics and dynamics, robot control, robot programming, mechatronics. Furthermore, good attitude for simulation and experimental work is mandatory. The candidates must have very good Matlab/Simulink programming skills, confidence with robotic hardware and be capable to conduct experiments, attitude to problem solving, and be strongly motivated for team working.

References:

- Matheson, E., Minto, R., Zampieri, E. G. G., Faccio, M., & Rosati, G. (2019). Human-robot collaboration in manufacturing applications: A review. Robotics, 8(4).
- Faccio, M., Minto, R., Rosati, G., & Bottin, M. (2020). The influence of the product characteristics on human-robot collaboration: A model for the performance of collaborative robotic assembly. International Journal of Advanced Manufacturing Technology, 106(5-6), 2317-2331.
- Rosati, G., Minto, S., & Oscari, F. (2017). Design and construction of a variable-aperture gripper for flexible automated assembly. Robotics and Computer-Integrated Manufacturing, 48, 157-166.

Number of positions available:

1

Main Research Site
Dipartimento di Ingegneria Industriale, via Venezia 1, I-35131 Padova, Italy

Contacts:
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Funding Scheme: This doctorate grant is co-funded by the proponent research institution and by the Italian Ministry of Research, under law D.M. 351/2022 (PNRR).

14. Planning and control strategies for robotic manipulators embedding elastic elements for efficient manipulation – Univ. Pisa

Curriculum: Industry 4.0

Hosting Institution
University of Pisa

Department:
Research Centre "E. Piaggio"

Tutor(s):
Prof. Paolo Salaris, Prof. Manolo Garabini and Dr. Franco Angelini

Description:

The research activity targets the motion planning and control of elastic robotic arms for efficient manipulation, including picking of static or moving objects and placing or throwing at a desired destination. The overall goal is to design actions that optimize performance indicators including: cycle time of picking and placing tasks in case of both moving or fixed objects, maximum speed and distance of throwing, and success rate of picking moving objects as well as of placing and throwing them into moving or fixed boxes.

These research activities will be developed within the EU H2020 project *DARKO (Id: 101017274)*, of which the Research Centre Enrico Piaggio of the University of Pisa is partner. *DARKO* sets out to realize a new generation of agile production robots that have energy-efficient elastic actuators to execute highly dynamic motions; are able to operate safely within unknown, changing environments; are easy (cost-efficient) to deploy; have predictive planning capabilities to decide for most efficient actions while limiting associated risks; and are aware of humans and their intentions to smoothly and intuitively interact with them. DARKO will demonstrate, in relevant scenarios, autonomous capabilities significantly beyond the current state of the art in dynamic manipulation (e.g., throwing of goods, picking, and placing objects while in motion), perception, mapping, risk management, motion planning and human-robot interaction.

Requirements:
For the reasons above, the successful candidate should ideally have a MSc in robotics and automation engineering, or a related field, with a strong background in control theory, planning, robotics and mathematics. Demonstrated experience with optimal control theory and programming (ROS1/ROS2, python, C/C++, Matlab) as well as experience in controlling compliant actuators is a plus.

References:

- M. Garabini, A. Passaglia, F. A. W. Belo, P. Salaris, and A. Bicchi. *Optimality principles in variable stiffness control: the VSA hammer*. In IEEE/RSJ International Conference on Intelligent RObots and Systems (IROS), pages 3770 – 3775, 2011.
- M. Garabini, F. A. W. Belo, P. Salaris, A. Passaglia, and A. Bicchi. *Optimality principles in stiffness control: The VSA kick*. In IEEE International Conference of Robotics and Automation (ICRA), pages 3341–3346, 2012.
- A. Velasco, G. M. Gasparri, M. Garabini, L. Malagia, P. Salaris, and A. Bicchi. *Soft actuators in cyclic motion: Analytical optimization of stiffness and pre-load*. In IEEE-RAS International Conference on Humanoid Robots (Humanoids), pages 354–361,

2013.
- A Palleschi, M Hamad, S Abdolshah, M Garabini, S Haddadin, L Pallottino. *Fast and safe trajectory planning: Solving the cobot performance/safety trade-off in human-robot shared environments*. IEEE Robotics and Automation Letters 6 (3), 5445-5452.
- A Palleschi, R Mengacci, F Angelini, D Caporale, L Pallottino, A De Luca, M Garabini. *Time-optimal trajectory planning for flexible joint robots*. IEEE Robotics and Automation Letters 5 (2), 938-945.
- F. Angelini et al., "*Decentralized Trajectory Tracking Control for Soft Robots Interacting With the Environment*", in IEEE Transactions on Robotics, vol. 34, no. 4, pp. 924-935, Aug. 2018.

Number of positions available:

1

Main Research Site
Research Centre "E. Piaggio": https://www.centropiaggio.unipi.it
DARKO EU project: https://darko-project.eu

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Funding Scheme: This doctorate grant is fully funded by the proponent research institution

15. Robotic trajectory planning for industrial sustainability – Univ. Udine

Curriculum: Industry 4.0

Hosting Institution
Università degli Studi di Udine

Department:
DPIA – Dipartimento Politecnico di Ingegneria e Architettura

Tutor(s):
Prof. Alessandro Gasparetto
Prof. Agostino Dovier

Description:
Digital and environmental transition are two fundamental topics that will shape our next future. In the industrial sector, these themes find their place within the concept of "industrial sustainability", which will allow to have a more efficient production and at the same time a reduced impact on the environment.
Robotics is one of the enabling technologies that will allow to pursue this goal. This research theme will focus on studying and implementing methodologies that will make the industrial processes more sustainable, especially in terms of production costs and energy consumption.
In particular, trajectory planning is a topic of crucial importance for industrial and collaborative robots. The availability of last-generation sensors, cyber-physical connections within the production plants and Artificial Intelligence techniques will allow to implement novel algorithms, that can obtain performances that were unexpected before.

Since the birth of robotics it emerged also the need of high level languages for modeling the problems that the robot(s) should solve applying sequences of their actions (a plan). These languages, often referred as action description languages, or languages for planning, need a solver for looking for the, possibly shorter, plan. Recent versions of these languages that allow to deal with multi-agent (multi-robot) systems include epistemic and also ethical reasoning capabilities. This area of research has still many very active subfields, including language definition and translation, audio-video interfaces, post processing of high level plans into sequences of ROS instructions, and development of solvers for planning that might take advantage from the parallelism of GPU.

The research activity will be carried out in the robotics laboratory available at the University of Udine, in laboratories of partner institutions and possibly within production plants of industrial companies, where the implemented methodologies can be tested on the field.

Requirements:
Applicants are not required to have a background in robotics. Knowing basic concepts of robotics, and having programming abilities in high-level programming languages (C, Python, ROS) is a plus. Knowledge of languages for planning (action languages, PDDL), of their intrinsic complexity, and of their main solving techniques is also a plus.

References:

- Vidussi, F., Boscariol, P., Scalera, L., and Gasparetto, A. "Local and Trajectory-Based

Indexes for Task-Related Energetic Performance Optimization of Robotic Manipulators". ASME. Journal of Mechanisms and Robotics, April 2021; 13(2): 021018. https://doi.org/10.1115/1.4049972

- Scalera, L., Boscariol, P., Carabin, G., Vidoni, R., Gasparetto, A. "Enhancing energy efficiency of a 4-DOF parallel robot through task-related analysis". Machines 2020, 8(1), 10, pp. 1-14; https://doi.org/10.3390/machines8010010
- L. Scalera, I. Palomba, E. Wehrle, A. Gasparetto, R. Vidoni "Natural Motion for Energy Saving in Robotic and Mechatronic Systems". Applied Sciences, 9(17), 3516; https://doi.org/10.3390/app9173516, pp. 1-26, August 2019
- A. Gasparetto, A. Lanzutti, R. Vidoni, V. Zanotto "Experimental validation and comparative analysis of optimal time-jerk algorithms for trajectory planning" Robotics and Computer-Integrated Manufacturing, Volume 28, Issue 2, April 2012, pp. 164-181, DOI: 10.1016/j.rcim.2011.08.003
- A. Gasparetto, V, Zanotto "A New Method for Smooth Trajectory Planning of Robot Manipulators" Mechanism and Machine Theory, vol. 42, April 2007, pp. 455-471
- Alessandro Burigana, Francesco Fabiano, Agostino Dovier, Enrico Pontelli. "Modelling Multi-Agent Epistemic Planning in ASP". Theory Pract. Log. Program. 20(5): 593-608 (2020) https://doi.org/10.1017/S1471068420000289
- Ferdinando Fioretto, Agostino Dovier, Enrico Pontelli "Distributed multi-agent optimization for smart grids and home automation" Intelligenza Artificiale 12(2): 67-87 (2018) https://doi.org/10.3233/IA-180037
- Roman Barták, Lukás Chrpa, Agostino Dovier, Jindrich Vodrázka, Neng-Fa Zhou. "Modeling and solving planning problems in tabled logic programming: Experience from the Cave Diving domain" Sci. Comput. Program. 147: 54-77 (2017) https://doi.org/10.1016/j.scico.2017.04.007
- Alessandro Dal Palù, Agostino Dovier, Andrea Formisano, Enrico Pontelli. "CUD@SAT: SAT solving on GPUs." J. Exp. Theor. Artif. Intell. 27(3): 293-316 (2015) https://doi.org/10.1080/0952813X.2014.954274
- Neng-Fa Zhou, Roman Barták, Agostino Dovier. "Planning as tabled logic programming" Theory Pract. Log. Program. 15(4-5): 543-558 (2015) https://doi.org/10.1017/S1471068415000216
- Agostino Dovier, Andrea Formisano, Enrico Pontelli. "Autonomous agents coordination: Action languages meet CLP(FD) and Linda" Theory Pract. Log. Program. 13(2): 149-173 (2013) https://doi.org/10.1017/S1471068411000615
- Agostino Dovier, Andrea Formisano, Enrico Pontelli. "Perspectives on Logic-Based Approaches for Reasoning about Actions and Change" Logic Programming, Knowledge Representation, and Nonmonotonic Reasoning, Springer Verlag, 2011: 259-279 https://doi.org/10.1007/978-3-642-20832-4_17
- Agostino Dovier, Andrea Formisano, Enrico Pontelli. "Multivalued action languages with constraints in CLP(FD)" Theory Pract. Log. Program. 10(2): 167-235 (2010) https://doi.org/10.1017/S1471068410000013

Company name and link (for industrial projects): N/A

Number of positions available:

1

Main Research Site

DPIA – Dipartimento Politecnico di Ingegneria e Architettura, Via delle Scienze 206, 33100 Udine - Italy

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Funding Scheme: This doctorate grant is co-funded by the proponent research institution and by the Italian Ministry of Research, under law D.M. 351/2022 (TD).