I-RIM

PhD Course in

ROBOTICS AND INTELLIGENT MACHINES

Curriculum: Robotics and Intelligent Machines for Industry 4.0

Research themes

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[1]

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

[1] (*) This grant is co-funded by Regione Liguria.

need of products customization, 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 digitized 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 characterized 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 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 a 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 students can contact the tutors and/or the Unit's Principal Investigators for clarifications before submitting their documentation.

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

1. Innovative mechatronic solutions for robotics and automatic machines– University of Bologna

Curriculum: Industry 4.0

Hosting Institution
University of Bologna

Department:
Department of Industrial Engineering

Tutors
Rocco Vertechy and Marco Carricato

Description
This PhD position concerns the conception, development and validation in relevant environments of mechatronic solutions to improve the performances of robots and automatic machinery.
The research should address one of the following:

1) Control systems for collaborative mobile manipulators that fuse the information from a multitude of sensors (load cells, IMU, TOF depth cameras, LIDAR, etc.) to interact effectively and safely with human operators. The intended application of the collaborative mobile manipulator to be implemented and experimentally tested in the project is the assembly of hypercar interiors and exteriors.
2) Soft sensors and actuators made in polymeric materials and realized via printed electronics techniques (3D-, screen-, inkjet- and piezojet-printing, as well as micro-dispensing, coating and deposition, all available at the University of Bologna). Foreseen applications of the sensors and actuators to be implemented and experimentally tested in the project are: space satellites; automated machinery for the packaging of food/pharma/electronics; healthcare and biomedical devices.
3) Soft grippers for the handling of fragile objects based on unconventional principles (electro-adhesion, gecko-effect, etc.). Foreseen applications of the gripers to be developed are: automated machinery for the packaging of food/pharma/electronics; docking systems for spacecraft.

Conception and development activities will be conducted at the Laboratory of Sensors and Actuators for Advanced Manufacturing, a joint research center between the University of Bologna and the STIIMA Institute of the National Research Council of Italy. Validation will be performed in partnership with major companies in the fields of automated packaging machinery, automotive, space and biomedical around the Bologna area in the context of existing research projects.

Requirements
Applicants should have an engineering degree in one of the following: automation, mechatronics, mechanics, computer science, electrical and electronics. For activities (2) and (3), a degree in physics and chemistry will also be welcomed. Fluency in English is required.
Attitude to problem-solving and collaborative work, high motivation, and passion for multidisciplinary research at the intersection of design, modeling, simulation and experimental prototyping and testing are highly recommended.
Possession of some of the following skills is preferable: robotics, mechatronics, programming, numerical simulation, mechanical and/or electronics prototyping, physics-based modeling, control theory, electronics, electrostatics, continuum mechanics, polymer processing.

Knowledge of some of the following is preferable: Matlab/Simulink, C/C++, ROS, CAD software, FEA software.

References

- Berdozzi, N., Chen, Y., Luzi, L., Fontana, M., Fassi, I., Tosatti, L. M., Vertechy, R. (2020). Rapid fabrication of electro-adhesive devices with inkjet printed electrodes. *IEEE Robotics and Automation Letters*, *5*(2), 2770-2776.
- Sîrbu, I. D., Moretti, G., Bortolotti, G., Bolignari, M., Dirè, S., Fambri, L., Vertechy, R., Fontana, M. (2021). Electrostatic bellow muscle actuators and energy harvesters that stack up. *Science Robotics*, *6*(51), eaaz5796.
- Avallone, G., Monari, E., Chen, Y., Agostini, L., Sancisi, N., Vertechy, R. (2022, June). A COBOT-IMU Hand-Guiding System with Online Collision Avoidance in Null Space. In *ROMANSY 24-Robot Design, Dynamics and Control: Proceedings of the 24th CISM IFToMM Symposium* (pp. 151-159).

Number of positions available: 1

Main Research Site

Laboratory of Sensors and Actuators for Advanced Manufacturing
Department of Industrial Engineering – University of Bologna
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Contacts

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Funding Scheme

This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Ricerca PNRR)

2. Optimal motion planning for redundant and adaptive industrial collaborative robotic systems – Free University of Bozen-Bolzano

Curriculum: Industry 4.0

Hosting Institution
Free University of Bozen-Bolzano

Department
Faculty of Engineering

Tutor
Renato Vidoni

Description

Background/Introduction
Industrial Collaborative robotics is one of the keys and enabling technologies of modern manufacturing. Since prevention from mechanical hazards is justifiably perceived as the primary requirement, cognitive ergonomics and human factors are often overlooked when developing collaborative systems. Consequently, companies must consider cognitive ergonomics to develop human-centered and efficient collaborative systems since, in the future, even more workers will collaborate with intelligent industrial robots to perform their job. The European Commission recently outlined the primary objectives of Industry 5.0: The human-centric strategy emphasizes how technology must be used to adjust the work to the state and behavior of the users. That means that manufacturing systems need to adapt (in real-time) to accommodate the variety of requirements of employees. Given the requirements of Industry 5.0 and the potential of advanced collaborative robotics, it is essential to build and use machines in a way that they consider the requirements of operators in terms of safety and well-being.

Project
This project aims at developing task and motion planning methodologies for industrial collaborative robotic systems that satisfy and adapt to counteracting and possibly changing requirements in terms of performance (e.g. speed) and mechanical safety as well as take into account the cognitive effects of the advanced robot system and related human interaction. In order to achieve this result, a key role will be played by the redundancy and its exploitation both in terms of kinematics (e.g. redundant manipulator, mobile manipulator, …) and in terms of actors that can perform an action (e.g. humans and/or robots).

Requirements
Applicants are expected to have a background in the areas of mechanical, electrical or computer engineering, or related fields. Previous experience in areas such as industrial (collaborative) robotics, sensor fusion, computer programming (e.g. Python, Matlab, ROS) and mechatronics and embedded systems development is desired. The candidate is expected to have analytical, communication, and writing skills as well as to be able to work in a multi-disciplinary environment with other PhD and undergraduate students, as well as Post-docs and faculty members.

References

- Scalera, L., Vidoni, R., Giusti, A., Optimal scaling of dynamic safety zones for collaborative robotics (2021) Proceedings - IEEE ICRA, 2021-May, pp. 3822-3828.
- Gualtieri, L., Rauch, E., Vidoni, R., Development and validation of guidelines for safety in human-robot collaborative assembly systems (2022) Computers and Industrial Engineering, 163, art. no. 107801.
- Rojas, R.A., Vidoni, R., Designing Fast and Smooth Trajectories in Collaborative Workstations (2021) IEEE RAL, 6 (2), art. no. 9353211, pp. 1700-1706.

Number of positions available: 1

Main Research Site
Smart Mini Factory Laboratory, Faculty of Engineering, Free University of Bozen-Bolzano, via Rosmini, 39100 Bolzano (I)

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Funding Scheme
This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Ricerca PNRR)

3. New methods for realistic and comfortable experiences in AR – Universita' di Genova

Curriculum: Industry 4.0

Hosting Institution
University of Genoa

Department
Department of Informatics, Bioengineering, Robotics, and Systems Engineering (DIBRIS)

Tutors
Silvio P. Sabatini, Andrea Canessa, Gerrit Maus, Agostino Gibaldi

Description
Optical see-through (OST) augmented reality head-mounted displays (HMD) have emerged as a key asset in several application fields. In OST HMDs the direct view of the world is mostly preserved and there is no perspective conversion in viewpoint and field of view, as with video see-through (VST) systems. This aspect confers a clear advantage over VST solutions, particularly when used to interact with close objects. Although there have been significant improvements to performance and comfort of OST HMDs, limitations associated with human perception still remain to be addressed. In order to provide the user with a realistic, natural and comfortable visual experience, a thorough and accurate knowledge of eye characteristics and HMD geometry must be assumed. These quantities are usually calibrated on a per-device and per-user basis, or modeled from scientific literature. A deviation of the actual values from the expected ones can result in incorrect camera placement, spatial distortions and non-uniformities, thus triggering discomfort in VR/AR.
The goal of this research project is to develop methods and techniques to assess and mitigate discomfort and perceptual inconsistencies between real and augmented visual content in OST HMDs. A joint experimental and modeling approach will be followed in order to:

1. investigate methods to evaluate different sources of discomfort/mismatch;
2. develop subjective and objective methods to quantify the originated discomfort;
3. investigate strategies to mitigate the sources of discomfort/mismatch in AR/VR devices

Requirements
Applicants are expected to:

1) have a keen interest in Vision Science and in Augmented Reality,
2) have good programming skills in at least one language (Matlab, C/C++, Python, C#),
3) work well in group problem solving situations,
4) have intermediate communication skills (oral and written) in English or better.

Experience in Unity 3D is a plus.

References

- Konrad, R., Angelopoulos, A., & Wetzstein, G. (2020). Gaze-contingent ocular parallax rendering for virtual reality. ACM Transactions on Graphics (TOG), 39(2), 1-12
- Lambooij, M. T., IJsselsteijn, W. A., & Heynderickx, I. (2007). Visual discomfort in stereoscopic displays: a review. Stereoscopic Displays and Virtual Reality Systems XIV, 6490, 183-195.

- Gibaldi A., Liu Y., Kaspiris-Rousellis C., Mahadevan M., Vlaskamp B.NS, Maus G.W. Vertical vergence and screen alignment with see-through head-mounted displays. ECVP 2023.

Company name and link (for industrial projects)
Magic Leap Inc. (www.magicleap.com)

Number of positions available: 1

Main Research Sites
- DIBRIS, via Opera Pia 13, 16145 Genoa, Italy
- Magic Leap Inc., Andreasstrasse 5, 8050 Zürich, Switzerland

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Funding Scheme
This doctorate grant is co-funded by PNRR program DM-117

4. Shared control for robotic assisted drilling tasks – University of Genoa

Curriculum: Industry 4.0

Hosting Institution
University of Genoa

Department
Dept. of Mechanical Engineering (DIME)

Tutors
Giovanni Berselli and Elena De Momi

Description
The project is aimed at implementing a shared controlled framework for robotic assisted drilling tasks. In order to achieve this main goal, the candidate will design and develop an innovative and modular drilling tool to be safely secured to the serial robot end-effector. In addition, an adaptive control will be designed and develop, to change the serial robot impedance parameter in order to allow for an accurate task execution. A possible use case will be spinal surgery, to safely perform laminectomy procedures. In this use case, the robot end-effector is in contact with different layers of tissue characterized by different stiffness parameters

Requirements
Applicants are expected to have a background in control, mechanics or bioengineering and to implement a multidisciplinary approach in order to reach the project aims.

References

- Su, H., Qi, W., Hu, Y., Karimi, H. R., Ferrigno, G., & De Momi, E. (2022). An incremental learning framework for human-like redundancy optimization of anthropomorphic manipulators. IEEE Transactions on Industrial Informatics, 18(3), 1864-1872. doi:10.1109/TII.2020.3036693
- Segato, A., Calimeri, F., Testa, I., Corbetta, V., Riva, M., & De Momi, E. (2022). A hybrid inductive learning-based and deductive reasoning-based 3-D path planning method in complex environments. Autonomous Robots, 46(5), 645-666. doi:10.1007/s10514-022-10042-z
- Fu, J., Palumbo, M.C., Iovene, E., Qingsheng, L., Burzo, I., Redaelli, A.L., Ferrigno, G., De Momi, E. (2023) Augmented Reality-Assisted Robot Learning Framework for Minimally Invasive Surgery Task 2023 IEEE International Conference on Robotics and Automation (ICRA

Number of positions available: 1

Main Research Sites
Leonardo Robotics Lab, Building 7, Politecnico di Milano, Italy (www.nearlab.polimi.it)

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5. Cyber-physical social security applied to emergent innovative technologies – University of Genoa and Italian Institute of Technology

Curriculum: Industry 4.0

Hosting Institution
- University of Genoa
- Istituto Italiano di Tecnologia

Department
- Department of Computer Science, Bioengineering, Robotics and Systems Engineering (Dibris at uniGE)
- Informatics and Communication Technology (ICT at IIT)

Tutors
Francesco Rea, Alessandra Sciutti, Stefano Bencetti, Nicoletta Noceti

Description
The field of cyber security is a fast-growing discipline that impacts on the interaction between people and technology. Even though the effectiveness of security measures to protect personal data is increasing, people remain susceptible to manipulation and thus the human element remains the weakest link: social engineering. Such weakness is often exploited by the use of various manipulation techniques aiming at the disclosure of sensitive information, namely social engineering. The field of social engineering is still in its early stages however the interaction between individuals and new technologies (assistive robotics, robot companion) and new ways of working (smart working) might be exposed to yet unknown risks associated with the misuse of protected data only partially addressed by traditional computer security. The overall aim of the project is to investigate how to prevent disclosure of sensitive information applied to the areas where humans use interconnected technologies (e.g. robotics, IOT, Big Data Analytics systems) especially in the context of human machine interactions (e.g.: robot companion, assistive robotics, home assistance, etc.). The aim unfolds into two goals for the candidate. First, the ideal candidate is required to develop algorithms of human machine interaction relying on cutting-edge machine learning techniques that allow the artificial intelligence to adapt to the person. For example, the assistive robot autonomously adapts the data acquisition strategy to the goal of improving the provided assistance without the acquisition of personal data, which is irrelevant to the assistance. The second goal is to improve the robustness and high integrity of system architectures (cyber-physical security) relying also on computer vision and adopted for above-mentioned cutting-edge technologies. The solutions defined by the candidate can also help the management of security risk and the analysis of social engineering threats.

As outcome of the project, such methodologies will be concretely applied to innovative applications especially involving robotics technologies designed at the Istituto Italiano di Tecnologia to make the applications socially aware and socially acceptable.

Requirements
Applicants are expected to have very good skills in at least two of the following areas: software development, computer vision, robot programming, machine learning. Furthermore, good attitude for experimental work is mandatory. The candidates must have: very good programming skills with different languages (including C/C++, Python, Matlab/Simulink); be

capable to conduct experiments; attitude to problem solving, and be strongly motivated for team working.

References

- Pasquali D., Gonzalez-Billandon J., Aroyo A.M., Sandini G., Sciutti A., Rea F. (2021). Detecting Lies is a Child (Robot)'s Play: Gaze-Based Lie Detection in HRI. International Journal of Social Robotics
- Pasquali D., Gonzalez-Billandon J., Rea F., Sandini G., Sciutti A. (2021). Magic iCub: A humanoid robot autonomously catching your lies in a card game. ACM/IEEE International Conference on Human-Robot Interaction
- Pasquali D., Sciutti A., Sandini G., Bencetti S., Rea F. (2022); Toward a Human-Oriented Social Engineering Defense System; Workshop: AI for Cybersecurity, Second CINI National Conference on Artificial Intelligence (Ital-IA).

Number of positions available: 1

Main Research Sites

Istituto Italiano di Tecnologia, Via Morego, 30 16163 Genova – Italy CONTACT - COgNiTive Architecture for Collaborative Technologies (IIT) https://www.iit.it/it/web/cognitive-architecture-for-collaborative-technologies/home

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Funding Scheme

This doctorate position is fully funded by the proponent research institution.

6. I4.0 intelligent robotic manufacturing cells – University of Modena and Reggio Emilia

Curriculum: Industry 4.0

Hosting Institution
Università degli studi di Modena e Reggio Emilia

Department
Dipartimento di Scienze e Metodi dell'Ingegneria (DISMI)

Tutor
Marcello Pellicciari

Description
The research aims at the development of novel engineering methods and tools for intelligent robotic manufacturing cells implementing the technologies and principles of industry 4.0. Novel Digital Twins and control/programming algorithms will be defined and validated to empower robotic cells with the intelligence needed to execute complex and ever-varying processes adopting Zero-Defect manufacturing approaches, achieving the highest productivity and manufacturing quality.
The PhD candidate will thoroughly examine the latest advancements in the field and devise innovative solutions that address the following objectives:

- Assess and predict the motion and manufacturing accuracy of industrial robots and industrial machinery, adopting both model-based and data-driven approaches. By incorporating theoretical knowledge with experimental data, a comprehensive understanding of the robotic systems' behavior will be attained, enabling precise predictions and optimizations.
- Real-time compensation of robot and servomotor dynamic disturbs and related accuracy errors by using online metrological feedback. By implementing additional sensors and adaptive algorithms, errors will be properly identified and rectified on the fly, ensuring consistent and reliable performance.
- Develop Digital Twins of several industrial robotics cells (assembly, machining, welding) with optimal scheduling engines and automatic code generation, allowing real-time process planning and optimal accuracy execution.
- Implement Zero defect intelligent robotic manufacturing processes (repairing strategies, manufacturing accuracy error detection and compensation approaches, robust control quality mechanisms) at TRL7.

Requirements
- Applicants are expected to have a strong attitude to research and team working
- MSc degree in Mechatronic / Mechanical / Automation / Robotic Engineering (preferably with a thesis work in Robotics, Mechatronics or Computer Science).
- Knowledge of topics related to
  - industry 4.0: technologies and principles
  - industrial robotics and automation
  - programming: Matlab/Python, PLC and robot programming
  - numerical modelling, data processing and simulation

References

- Khaled, T. A., Akhrif, O., & Bonev, I. A. (2020). Dynamic path correction of an industrial robot using a distance sensor and an ADRC controller. IEEE/ASME Transactions on Mechatronics, 26(3), 1646-1656.
- Bilancia, P., Monari, L., Raffaeli, R., Peruzzini, M., & Pellicciari, M. (2022). Accurate transmission performance evaluation of servo-mechanisms for robots. Robotics and Computer-Integrated Manufacturing, 78, 102400.
- Gadaleta, M., Pellicciari, M., & Berselli, G. (2019). Optimization of the energy consumption of industrial robots for automatic code generation. Robotics and Computer-Integrated Manufacturing, 57, 452-464.
- Verl, A., & Steinle, L. (2022). Adaptive compensation of the transmission errors in rack-and-pinion drives. CIRP Annals, 71(1), 345-348.
- Cvitanic, T., & Melkote, S. N. (2022). A new method for closed-loop stability prediction in industrial robots. Robotics and Computer-Integrated Manufacturing, 73, 102218

Number of positions available: 1

Main Research Site

- XiLAB – X-in-the-Loop Simulation Lab

Contacts

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Funding Scheme: This doctorate grant is funded by PNRR program DM-118 (action 4.1 – PNRR)

7. Human- and environment-robot interaction with soft manipulators - Università di Roma Sapienza

Curriculum: Industry 4.0

Hosting Institution
Sapienza University of Rome

Department
Department of Computer, Control and Management Engineering (DIAG)

Tutor
Alessandro De Luca

Description

The next generation of robots will consist of intelligent machines highly adaptable to the environment and compliant in their structure, that will physically interact with human operators and with unstructured environments, operate safely in their workspace and with reduced energy consumption, and display smooth, natural, and dynamically efficient controlled motion: the new paradigm will be that of soft robots [1,2], with a large variety of possible applications (from surgical to underwater robots, to safe collaboration with human operators in industrial settings). The class of soft robots encompasses different realizations, including lightweight manipulators with flexible joints [3] and/or distributed flexibility along the links [4], or with variable stiffness actuation [5], as well as robotic structures with continuously deformable elements [6-8].

The dynamics of these robots shares some properties that are relevant for addressing control problems, e.g., they may be underactuated (with a number of independent control commands smaller than that of generalized coordinates) or become (at the same time) hyper-redundant with extra DOFs with respect to the task variables of interest, or display collocated or non-collocated characteristics, depending on the system variables to be controlled (outputs) and the location of the actuation commands (inputs).

The objective of this doctoral research project is to advance the state-of-the-art on dynamic control of soft robots, considering different problems that have already been addressed and solved (by the proposing research group and by others) in more conventional rigid robots (see, e.g., [9-14]). For example, the following open problems could be considered for the general class of soft robots:

a) Sensorless collision detection, isolation, and reaction.
b) Energy-efficient motion control by considering underactuation.
c) Model-based accurate trajectory tracking at the task level, with stable zero dynamics.
d) Force and impedance control for a generic contact location along the soft structure.
e) Learning schemes for regulation tasks and for repetitive trajectory tracking, under largely uncertain dynamics

Requirements

We look for applicants with a master's degree in Control Engineering, Artificial Intelligence and Robotics, Mechanical Engineering, or Computer Science. Different backgrounds will be taken also into account, provided that the candidate has received basic education in modeling and control of dynamic systems and in robotics. Applicants are also expected to possess programming skills in the most common languages (C++, MATLAB, Python), and familiarity with ROS and with robotic simulation environments

References

[1] C. Laschi, M. Cianchetti, B. Mazzolai, L. Margheri, M. Follador, and P. Dario (2012). Soft robot arm inspired by the Octopus. Advanced Robotics, 26, 709–727. doi:10.1163/156855312X626343

[2] I.D. Walker, H. Choset, and G.S. Chirikjian (2016). Snake-like and Continuum Robots. In: B. Siciliano and O. Khatib (Eds.), Springer Handbook of Robotics (2nd Ed), 481–498, Springer. doi:10.1007/978-3-319-32552-1_20

[3] A. De Luca and W. Book (2016). Robots with Flexible Elements. In: B. Siciliano and O. Khatib (Eds.), Springer Handbook of Robotics (2nd Ed), 243-282, Springer. doi:10.1007/978-3-319-32552-1_11

[4] A. De Luca and B. Siciliano (1991). Closed-form dynamic model of planar multi-link lightweight robots. IEEE Trans. on Systems, Man, and Cybernetics, 21, 826–839. doi:10.1109/21.108300

[5] A. Albu-Schäffer and A. Bicchi (2016). Actuators for Soft Robotics. In: B. Siciliano and O. Khatib (Eds.), Springer Handbook of Robotics (2nd Ed), 499-530, Springer. doi:10.1007/978-3-319-32552-1_21

[6] S. Hirose and H. Yamada (2009). Snake-like robots. IEEE Robotics and Automation Mag., 16, 88-98. doi:10.1109/MRA.2009.932130

[7] C. Della Santina (2019). Natural Principles for the Design and Control of Soft Robots. PhD Thesis, Università di Pisa, June 2019.

[8] J. Burgner-Kahrs, D.C. Rucker, and H. Choset (2015). Continuum robots for medical applications: A survey. IEEE Transactions on Robotics, 31, 1261–1280. doi:10.1109/TRO.2015.2489500

[9] S. Haddadin, A. De Luca, and A. Albu-Schäffer (2017). Robot collisions: A survey on detection, isolation, and identification. IEEE Trans. on Robotics, 33, 1292-1312. doi:10.1109/TRO.2017.2723903

[10] C. Gaz, A. Cristofaro, and A. De Luca (2020). Detection and isolation of actuator faults and collisions for a flexible robot arm. Proc. 59th IEEE Conf. on Decision and Control, 2684–2689. doi:10.1109/CDC42340.2020.9304299

[11] P. Pustina, P. Borja, C. Della Santina, and A. De Luca (2023). P-satI-D shape regulation of soft robots. IEEE Robotics and Automation Lett., 8, 1-8. doi:10.1109/LRA.2022.3221304

[12] A. De Luca, R. Mattone, and G. Oriolo (2000). Stabilization of an underactuated planar 2R manipulator, Int. J. of Robust and Nonlinear Control, 10, 181-198. doi:10.1002/(SICI)1099-1239(20000415)10:4<181::AID-RNC471>3.0.CO;2-X

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[14] A. De Luca and S. Panzieri (1996). End-effector regulation of robots with elastic elements by an iterative scheme. Int. J. of Adaptive Control and Signal Processing, 10, 379–393. doi:10.1002/(SICI)1099-1115(199607)10:4/5<379::AID-ACS369>3.0.CO;2-O

Number of positions available: 1

Main Research Site: DIAG Robotics Laboratory b

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8. Geometric and Physics-Aware Robot Learning for Contact-Rich Manipulation - Università di Trento

Curriculum: Industry 4.0

Hosting Institution
Università di Trento

Department
Department of Industrial Engineering

Tutor
Matteo Saveriano and Daniele Fontanelli

Description
Contact-rich robotic manipulation is still an unsolved problem, especially in open-ended environments. Existing approaches based on control techniques require accurate modeling of the system, which is a very complex task due to the contacts and uncertainties of the components involved. On the other hand, approaches that identify these models from data are effective but particularly complex and, consequently, very slow. Furthermore, most approaches in the literature do not consider that robotic manipulation data belong to curved (non-Euclidean) spaces and attempt to reconstruct the geometric structure of the space in a post-processing phase. This often introduces considerable distortions between the desired and the achieved robot's performance.
The goal of this research project is to develop a new class of "hybrid" learning algorithms in which a preliminary (but approximate) model is derived analytically and then refined using data. This approach will greatly increase the efficiency and robustness of the approach. Mathematical tools arising from Riemannian geometry will be exploited to preserve the geometric structure of the space in order to increase the accuracy. Finally, proper visual feedback will be integrated to further increase flexibility and robustness

Requirements
Applicants are expected to hold a Master Degree (or equivalent) in Control Engineering, Computer Engineering, or Computer Science with a specific focus on robotics. The candidate should have a strong mathematical background, advanced programming skills in Python and/or C++, and knowledge of existing robot learning approaches including mixture models and artificial neural networks. Knowledge of Riemannian geometry and Lie groups is welcomed.

References

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Number of positions available: 1

Main Research Site

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Funding Scheme This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Pubblica Amministrazione)

9. Robotic trajectory planning for industrial sustainability – Università di Udine

Curriculum: Industry 4.0

Hosting Institution
Università degli Studi di Udine

Department
DPIA – Dipartimento Politecnico di Ingegneria e Architettura

Tutors
Alessandro Gasparetto and 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

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- 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

Number of positions available: 1

Main Research Site
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Funding Scheme
This doctorate grant is funded by PNRR program DM-118 (action 4.1 – Ricerca PNRR)

10. Improve Human-Cobot Cooperation in the Automation of Made-in-Italy Craft Production – Polytechnic University of Marche

Curriculum: Industry 4.0

Hosting Institution
Polytechnic University of Marche

Department
Dept. Industrial Engineering & Mathematical Sciences (DIISM)

Tutor
Massimo Callegari

Description
The advancement of emerging countries in recent years cannot be denied but it impacted the field of Made-in-Italy less than other market sectors, since in this case the price factor is not the most important parameter for buyers. Rather, the focus is mainly on product quality and customization possibilities, two areas in which Italian creativity and know-how are unmatched in the world.

Therefore, the digital transition of small companies in this sector cannot fail to combine the potential of emerging technologies with the exploitation of the human capital and know-how available in the workshops, according to the guidelines of the Industry 5.0 paradigm [4, 5]. Only in this way will it be possible to overcome the main barrier that has so far hindered the full implementation of the "Fourth Industrial Revolution" in Italy, which is the small size of the companies [6].

This project aims at the development of collaborative robotic processes for making and finishing luxury craft products; it will develop new tools and new protocols for human-robot collaboration that, by taking advantage of the enabling technologies now available even at low cost, will allow a closer interaction between operator and machine and ultimately greater process efficiency in craft production [2].

The Ph.D. project may deal with the development of some of the following hw/sw components or modules:
- advanced human-cobot interfaces
- ergonomic evaluation of operator-robot cooperation
- motion tracking, reactive control and dynamic task planning
- smart end-effectors, exploiting IIoT capabilities and developed for specific applications
- modelling of behaviour of human operator
- programming in virtual environments via simulation and VR/AR (human-in-the-loop)

The following technologies will be used:
- Collaborative robotics
- Smart handling and processing tools
- Artificial Intelligence
- AR/VR for human in the loop
- 3D sensing and artificial vision

The experimental part of the research will be developed at the Laboratory of i-Labs Industry (https://ilabsindustry.it/) in Jesi (AN), an innovation infrastructure for the digital transition of SME's.

Requirements

The following disciplines are involved, at different grades, in the development of the Ph.D. project: Robotics; Control; Artificial Intelligence; Ergonomics; Mechatronics.

A solid background in all these subjects is not required but the candidates should be available to acquire all the needed competences during the development of the project.

Applicants should have a master degree in one of the following engineering subjects: automation, mechatronics, mechanics, computer science, electrical and electronics.

Knowledge of some of the following software tools is preferable: Matlab/Simulink, ROS, CAD software, multibody simulation.

Fluency in English is required. Moreover the candidates are expected to have attitude to problem solving and experimental work and be strongly motivated for team working.

References

1. ISO/TS 15066 (2016) "Robots and robotic devices — Collaborative robots"
2. Vicentini, F. (2021). "Collaborative Robotics: A Survey." ASME. J. Mech. Des.; 143(4)
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4. P. K. R. Maddikunta et al. (2022) "Industry 5.0: A survey on enabling technologies and potential applications," J Industrial Information Integration, vol. 26.
5. G. Schirner, D. Erdogmus, K. Chowdhury, and T. Padir (2013) "The Future of Human-in-the-Loop Cyber-Physical Systems," Computer (Long Beach Calif), vol. 46, no. 1, pp. 36–45.
6. D. Romero, J. Stahre, and M. Taisch (2020) "The Operator 4.0: Towards socially sustainable factories of the future," Computers & Industrial Engineering, vol. 139.
7. D. Mourtzis, J. Angelopoulos, and N. Panopoulos (2022) "Operator 5.0: A survey on enabling technologies and a framework for digital manufacturing based on extended reality," Journal of Machine Engineering, vol. 22.
8. F. I. Khawaja, A. Kanazawa, J. Kinugawa, and K. Kosuge (2021) "A Human-Following Motion Planning and Control Scheme for Collaborative Robots Based on Human Motion Prediction," Sensors, vol. 21, no. 24.

Number of positions available: 1

Main Research Site

- Dipartimento di Ingegneria Industriale e Scienze Matematiche, Ancona (I) (www.diism.univpm.it).
- Experiments will be conducted also at the i-LABS Industry Laboratory in Jesi, Ancona (I) (https://ilabsindustry.it/).

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Funding Scheme

This doctorate grant is fully funded by Polytechnic University of Marche

11. Integration of Machine Learning and Knowledge Representation for Digital Factory Twin applications – CNR-STIIMA

Curriculum: Industry 4.0	
Hosting Institution Consiglio Nazionale delle Ricerche	
Department: Intelligent Industrial Technologies and Systems for Advanced Manufacturing – STIIMA https://www.stiima.cnr.it/en/	
Tutor(s): Walter Terkaj Sara Arlati	

Description:

The new generation of intelligent manufacturing systems consists of the collaborative integration of humans, cyber and physical systems. In this context, Digital Twins are helpful for modeling complicated processes involving intelligent machines and humans, which interact together and with their environments, and for which it is difficult to predict outcomes.

Artificial Intelligence (AI) – both in terms of Machine Learning (ML) and Formal Knowledge Representation – and eXtended Reality (XR) are among the Digital Twin enabling technologies, and their combined use can boost the development of smart methodologies and tools addressing manufacturing engineering problems.

Given this, the goals of this research are:

(i) to use formal knowledge representation, in particular ontologies, to support ML and Deep Learning (DL) algorithms by providing well-structured data sets for training and testing, and

(ii) to integrate such outcomes in an interactable XR environment supporting human-machine collaboration activities thanks to advanced visual interfaces (e.g., by providing data-enriched visualization, support, and training to operators).

The combined AI approach is expected to bridge a gap between ML/DL algorithms, which offer great opportunities but require large data sets as inputs and miss interpretability and explainability ("black-box" model), and formal knowledge representation, which are transparent models supporting automatic reasoning and explanations, but require a significant effort to be built.

Regarding XR, such technology is aimed at improving the comprehension and user experience of the human operator while interacting with robots and intelligent machines. Given this, the PhD project foresees the design, development, and validation of a scenario exploiting the most appropriate technologies in terms of visualization and interaction. Such a scenario can also become an instrument to generate input data to feed into the AI algorithms when the factory or production system is not physically available or whenever it is not feasible or safe to create particular situations in the real world.

Requirements:

The candidate is expected to have:

- Good general coding skills

- Basic knowledge of Machine Learning
- Basic knowledge of data modeling (e.g., knowledge representation, databases, formal languages, ontologies)

Extra skills include:
- Programming skills in Python, JavaScript, C++, C#
- Prior experience with Machine Learning (Deep Learning) frameworks and knowledge of common frameworks and libraries (e.g., TensorFlow, Keras, PyTorch, etc.)
- Skills in 3D modeling and Virtual Reality frameworks or game engines (e.g., Babylon.js, Unity)
- Experience with tools for collaboration, visualization, and sharing (git repositories, Jupyter notebooks, 2D and 3D graphics, etc.)

References:

- Virtual Learning Factory Toolkit (VLFT), https://virtualfactory.gitbook.io/vlft/
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Company name and link (for industrial projects):

-

Number of positions available:

1

Main Research Site

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Funding Scheme: This doctorate grant is funded by CNR-STIIMA project “Metodologie e strumenti per la progettazione e gestione dell'impresa digitale” (ID), code DIT.AD008.163.

12. Micro-robotic manipulation and characterization of biological samples – CNR-STIIMA

Curriculum: Industry 4.0

Hosting Institution
Consiglio Nazionale delle Ricerche

Department:
Intelligent Industrial Technologies and Systems for Advanced Manufacturing – STIIMA
https://www.stiima.cnr.it/en/

Tutor(s):
Irene Fassi

Description:

The project aims at linking the latest developments in micro-technologies and particularly in micro-robotics and assembly to the industry 4.0 paradigms. The concepts of intelligent production are applied at the micro-scale for the development of innovative devices and processes for the assisted and automatic manipulation of micro-objects, using innovative model based control techniques and advanced vision based manipulation strategies.
The main research focus is on manipulation and characterization of small objects, below the millimetre dimension, which represents the lower limit of human dexterity.
The objective is to develop flexible robotic systems and methods, dedicated to small scales. The targeted applications, such as the assembly of high-precision sensors based on MEMS, or the manipulation of isolated biological samples, typically require human intervention, or concern work in small series. The robot and its controller must be designed for teleoperation and co-manipulation, while allowing completely manual or automatic phases. Several applications are possible in precision assembly, for example in watchmaking or jewellery. A target application concerns biology and the development of tools for the manipulation, characterization and injection of biological material into individual cells or other similar samples such as fish or insect eggs, between 10 µm and 1.3 mm. The approaches considered are vision, force control, haptics, data fusion, as well as any other "intelligent" learning method. Even if some easily adaptable solutions exist in the literature, their complete and ergonomic integration into a single system is still an ambitious goal. In addition, the heart of the project concerns the fine control of the mechanical interaction with the samples in a biocompatible environment. At present, there is no bio-compatible technology or method with the appropriate reliability, bandwidth, resolution and force range, due to the wide variety of samples and the difficulty of working in a liquid environment. A key part of the project is the development of such a device.

Requirements:

- The candidate is expected to have a Master degree in Mechanical Engineering, or Automation and Robotics, or Material Engineering, MEMS, Control, Electrical Engineering, or a related field.
- Students with strong analytical/computational skills are also encouraged to apply.

References:

- L Cohen, M Chetouani, S Régnier, S Haliyo (2018). A natural interface based on intention prediction for semi-autonomous micromanipulation. J on Multimodal User Interfaces. 12 - 1: pp17--30.
- M Yin, E Gerena, C Pacoret, S Haliyo, S Régnier (2017). High-bandwidth 3D Force Feedback Optical Tweezers for Interactive Bio- manipulation. 2017 IEEE/RSJ IROS, Vancouver, Canada
- A Mohand Ousaid, G Millet, G. S Haliyo, S Régnier, V Hayward (2015). A Stable and Transparent Microscale Force Feedback Teleoperation System. IEEE/ASME Trans. on Mechatronics . Vol 20 No 5 Pages 2593-2603.
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Company name and link (for industrial projects):
-

Number of positions available:
1

Main Research Site
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Funding Scheme: This doctorate grant is funded by CNR-STIIMA project “Micro Enabled Robotics and Technologies” (ID), code DIT.AD008.191.

13. Large Language Models in the Field of Industrial Automation – Università di Genova (*)

Curriculum: Industry 4.0
Hosting Institution Universita' di Genova
Department: DIBRIS
Tutor(s): Prof. Davide Anguita
Description: The application of "Large language models" in the field of industrial automation offers an unprecedented opportunity to improve the understanding and processing of data, allowing the creation of predictive models and the optimization of production processes. This represents a significant qualitative leap towards the integration of artificial intelligence technologies in the industrial context. In particular, the PhD course is based on an innovative methodology that uses artificial intelligence and machine learning for data collection and analysis. The use of the LLMs in the industrial context, which is still unexplored today, will be innovative for the development of advanced design methodologies.
Requirements: Applicants must have a good knowledge of AI and machine learning fundamentals. Applicants are also expected to have good programming skills (including Python, C/C++, Matlab/Simulink) and a strong attitude to problem solving.
References: -
Company name and link (for industrial projects): Saie s.r.l. - Savona
Number of positions available: 1
Main Research Site DIBRIS – Universita' di Genova Saie s.r.l. - Savona
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Funding Scheme: This doctorate grant is co-funded by Saie s.r.l. and Regione Liguria

14. Human-Robot collaboration – Università di Genova

Curriculum: Industry 4.0

Hosting Institution
Universita' di Genova

Department:
DIBRIS

Tutor(s):
Prof. Giorgio Cannata

Description:
Collaborative robots (COBOTS) are used in industrial and service applications to accomplish tasks where human-robot cooperation (i.e. sharing a common space) or collaboration (i.e. physically interacting to complete a common action) is required. During collaborative tasks robots are controlled using feedback from cameras, force/torque sensors, tactile sensors, proximity sensors etc. which allow the robot to localize itself and interact safely with humans and objects.
The PhD project has the goal of developing robot system capable to physically interact with a human to collaborate to execute jointly assembly operations. The scientific objective is to investigate human-robot interaction control strategies based on sensor feedback from cameras, tactile and proximity sensors (multimodal sensing) mounted on the robot arm, enabling safe interaction and touch based robot guidance
The experimental scenario is based on a dual-arm robot (sensorized using cameras, tactile and proximity sensors) mounted on a mobile platform sharing the space with a human operator to complete a series of operations involving contact of the robot with the environment.
This PhD research theme is part of the activities of the European project *HE Sestosenso* (www.sestosenso.eu)

Requirements:
Applicants must have a good knowledge of robotics fundamentals and robot programming. Applicants are also expected to have good programming skills (possibly including Python, C/C++, Matlab/Simulink), confidence with electronic hardware and be capable to conduct experiments, and a strong attitude to problem solving.

References:

- A. Albini, F. Grella, P. Maiolino and G. Cannata, "Exploiting Distributed Tactile Sensors to Drive a Robot Arm Through Obstacles," in IEEE Robotics and Automation Letters, vol. 6, no. 3, pp. 4361-4368, July 2021, doi: 10.1109/LRA.2021.3068110.
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- F. Grella, A. Albini and G. Cannata, "Voluntary Interaction Detection for Safe Human-Robot Collaboration," *2022 Sixth IEEE International Conference on Robotic Computing (IRC)*, Italy, 2022, pp. 353-359, doi: 10.1109/IRC55401.2022.00069.

Company name and link (for industrial projects):
-

Number of positions available: 1
Main Research Site DIBRIS – Universita' di Genova
Contacts: Email: giorgio.cannata@unige.it
Funding Scheme: This doctorate grant is co-funded by PNRR program DM-118 (action 4.1 – Ricerca PNRR)

15. Human/Robot collaboration in cooperative assembly tasks – Leonardo s.p.a. and Università di Genova

Curriculum: Industry 4.0

Hosting Institution
Universita' di Genova

Department:
DIBRIS

Tutor(s):
Prof. Giorgio Cannata (UNIGE)
Dr. Enrico Mingo Hoffman (LEONARDO)

Description:
The possibility to have a collaborative robot (cobot) sharing and collaborating with a human worker in performing typical industrial task is a fundamental paradigm for the Industry 4.0 program, e.g. during assembly tasks.
In this scenario, the cobot needs to understand the intention of the human worker understanding her/his needs according to the assembly phase while ensuring safety. The research will be focused on the development of a Human-Robot Collaborative Station (HRCS) for cooperative assembly tasks. In particular, the topic of collision avoidance and intention detection will be crucial in order to speed up the assembly while guarantee safety.

Requirements:
Applicants are expected to have good programming skills (possibly including Python, C/C++), confidence with electronic hardware and be capable to conduct experiments, and a strong attitude to problem solving.

References:

Company name and link (for industrial projects):
Leonardo S.p.a. – Genova (Innovazione e sviluppo tecnologie Leonardo Labs | Leonardo)

Number of positions available:
1

Main Research Site
DIBRIS – Universita' di Genova
Leonardo Labs - Genova

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Funding Scheme: This doctorate grant is co-funded by: PNRR program DM-117

16. Robotics and AI for electronic waste recycling– Università degli Studi di Genova (*)

Curriculum: Industry 4.0

Hosting Institution
University of Genoa

Department:
DIBRIS, Department of Informatics, Bioengineering, Robotics and Systems Engineering

Tutor(s):
Carmine Recchiuto, Antonio Sgorbissa, Davide Labolani, Jacopo Iottero

Description:
This Ph.D. work foresees a pioneering approach that combines artificial intelligence with robotics to address a growing challenge: E-Waste recycling [1],[2]. The issue of sorting batteries is very topical and relevant, given the growing diffusion of electric or hybrid vehicles and the consequent need to dispose of batteries that have reached the end of their life. Although this is a research topic in continuous development, at the moment there are no fully automated systems for the disassembly and disposal of heterogeneous batteries, also due to the lack of production standards. To date, the disassembly of the batteries is carried out almost entirely by hand by a specialized operator and it involves poor ergonomics and a high degree of risk for the operator, as the batteries contain toxic and dangerous substances and may contain residual charge [3]. Furthermore, given the monotony of the disassembly process and the high weight and bulk of the batteries of electric vehicles, this process is mentally and physically stressful for the operator. The implementation of artificial intelligence and planning algorithms, together with the interaction between robots and human operators, offers an unprecedented opportunity to increase efficiency and safety in the process of disassembling electric vehicle batteries [4],[5]. In particular, the Ph.D. student is expected to study, design and implement artificial intelligence strategies for the semi-automatic disassembly of electric vehicle batteries through human-robot and robot-robot interaction, using advanced collaborative robots (e.g. Universal Robots) and industrial systems.

The work will be partially performed at HIRO Robotics, an innovative startup based in Genoa that operates in the automation branch for the disassembly of electrical and electronic waste.
In particular, HIRO Robotics has developed various automation lines suitable for the disposal and sorting of WEEE waste such as flat screen monitors and electronic boards, thanks to the use of artificial intelligence algorithms and proprietary adaptive robot control. The company also holds several patents in this area.

Requirements:
Applicants are expected to have good programming skills (C++, Java, or Python) and a profound interest in cutting-edge research in autonomous robotics. Previous experience with Artificial Intelligence techniques and Human-Robot Interaction strategies will be considered.

References:

- [1] Grau Ruiz, M. A., & O'Brolchain, F. (2022). Environmental robotics for a sustainable future in circular economies. *Nature Machine Intelligence*, *4*(1), 3-4.
- [2] Kristensen, C. B., Sørensen, F. A., Nielsen, H. B., Andersen, M. S., Bendtsen, S. P., & Bøgh, S. (2019). Towards a robot simulation framework for e-waste disassembly using reinforcement learning. *Procedia Manufacturing*, *38*, 225-232.
- [3] Tarrar, M., Despeisse, M., & Johansson, B. (2021). Driving vehicle dismantling forward-A combined literature and empirical study. *Journal of Cleaner Production*, *295*, 126410.
- [4] Johnson, M., Khatoon, A., & Fitzpatrick, C. (2022, November). Application of AI and Machine Vision to improve battery detection and recovery in E-Waste Management. In *2022 International Conference on Electrical, Computer, Communications and Mechatronics Engineering (ICECCME)* (pp. 1-6). IEEE.
- [5] Choux, M., Marti Bigorra, E., & Tyapin, I. (2021). Task planner for robotic disassembly of electric vehicle battery pack. *Metals*, *11*(3), 387.

Company name and link (for industrial projects):
HIRO Robotics: https://www.hirorobotics.com/en/home/

Number of positions available:
1

Main Research Site
The research will be performed at the DIBRIS department in the "Laboratorium/Social Robotics Lab," a fully equipped facility for software development with ground robots (quadruped and wheeled), humanoid robots for socially assistive applications, and aerial robots, and at the HIRO Robotics laboratories, equipped with collaborative robots.

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Funding Scheme: This doctorate grant is funded by HIRO Robotics and Regione Liguria (PR Liguria FSE+ 2021-2027)

17. AI and robotics for innovative closure and capping systems in food and beverage industry – Politecnico di Bari

Curriculum: Industry 4.0

Hosting Institution
Politecnico di Bari

Department:
Dipartimento di Ingegneria Elettrica e dell'Informazione (DEI)

Tutor(s):
Prof. David Naso, Ing. Denis Ruffino, Prof. Paolo Massenio

Description:
The proposal focuses on innovation in the automation of packaging production plants for the "food and beverage" sector. AROL is one of the world players in the sector of machines with very high automation for the closing of packaging (bottles, cans, pouches) in various sectors of the international agri-food chain.

Currently, designing machines in this sector that are increasingly efficient in terms of product quality preservation, waste reduction, energy consumption, production time, and cost is fraught with scientific and technological challenges of multiple natures, which mostly fall within the scientific discipline of robotics and automation. The proposal is fully in line with 2 of the 32 technological development trajectories of national priority, specifically: "Intelligent and Sustainable Industry, Energy and Environment: Innovative Production Processes for High Efficiency and Industrial Sustainability" and "Health, Food, Quality of Life: Systems and Technologies for Packaging, Preservation, Tracing, and Safety of Food Productions."

The theme of the proposal is the development of intelligent machines that employ next-generation sensors and actuators to obtain closing processes with ever-increasing guarantees of product quality and at the same time lower costs and energy consumption. The topic, intrinsically multidisciplinary, involves the pursuit of an improvement in the closing operation through more sensorized robots capable of monitoring the main elements (environmental factors, characteristics of the package and cap, handling and sealing characteristics) that influence the quality of the closing while the operations themselves are underway, reducing the need for destructive post-checks.

The doctoral student will carry out studies of mathematical modeling, design of innovative sensory and actuation systems, and control algorithms based on the state of the art research on the subject. During the studies, the intelligent machine must be modeled as a complex hybrid process with partially continuous and partially event dynamics. The model and strategies for monitoring and controlling the machine must be realized in advanced modern programming and simulation environments suitable for rapid prototyping of decision and control algorithms based on the new paradigms of Reinforcement Learning and Artificial Intelligence in general, to allow for consistent innovation in both hardware and software of the machines.

The research activities in this field are the basis of a partnership agreement between AROL Spa and the Politecnico di Bari, which has led to the creation of the public-private laboratory "Cyber-physical systems" located at the joint research headquarters in Politecnico di Bari, where the student's activities will take place.

Requirements:
The ideal candidate must have in-depth knowledge of the fundamentals of automatic control, both in the continuous and discrete-time domains, as well as knowledge of electric drives and industrial robotics. The candidate will work on the design and prototyping of new robotic systems for closure operations with extended sensory equipment and advanced control algorithms, which exploit the available information to perform more efficiently. Learning and adaptive control will be also considered. The research activity will be carried out on development platforms based on Matlab/Simulink.

References:

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Company name and link (for industrial projects):
AROL S.p.A – Closure Systems, Viale Italia, nº193, Canelli 14053 (AT) Italy, www.arol.com

Number of positions available:
1

Main Research Site: Laboratorio Congiunto Politecnico di Bari- Arol S.p.A "Cyber-Physical Systems", Officine Politecniche, Via Amendola 132, 70126 Bari, www.arol.com

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