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 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. Learning and control for interactive robots – Istituto Italiano di Tecnologia

Curriculum: Industry 4.0

Hosting Institution
Istituto Italiano di Tecnologia

Department:
Human-Robot Interfaces and Interaction

Tutor
Arash Ajoudani

Description
The increasing demand for automation has driven the development of mobile robots capable of operating alongside humans in various settings. These robots require sophisticated learning and control capabilities to navigate dynamic environments, perform tasks autonomously, and collaborate effectively with humans. This PhD project will explore these critical areas:
Machine Learning for Robot Control: Develop novel machine learning algorithms to enable robots to learn dexterous manipulation skills, grasp objects with varying shapes and textures, and adapt their behavior to changing environments. This may involve reinforcement learning, deep learning techniques, and sensor-based feedback processing.
Motion Planning and Control: Design robust motion planning algorithms that ensure safe and efficient navigation in dynamic environments. This includes obstacle avoidance, path planning, and real-time adaptation to unforeseen situations. Additionally, develop control algorithms that guarantee precise and compliant motion during task execution and human interaction.
Human-Robot Collaboration: Research methods for robots to understand human intentions, anticipate human actions, and collaborate seamlessly in shared workspaces. This may involve incorporating human-robot communication protocols, natural language processing, and social interaction models.

Requirements
The successful candidate must have an MSc degree with a strong background in Robotics, Machine Learning 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

- Zhao, Jianzhuang, et al. "A hybrid learning and optimization framework to achieve physically interactive tasks with mobile manipulators." IEEE Robotics and Automation Letters 7.3 (2022): 8036-8043.
- Merlo, E., Lagomarsino, M., Lamon, E. and Ajoudani, A., 2023. Automatic Interaction and Activity Recognition from Videos of Human Manual Demonstrations with Application to Anomaly Detection. arXiv preprint arXiv:2304.09789

Number of positions available: 1
Main Research Site Center for Robotics and Intelligent Systems (CRIS), IIT, Genova
Contacts Email: Arash.ajoudani@iit.it
Funding Scheme This doctorate grant is funded by the Italian Institute of Technology
Scholarship Amount: ● Fascia 2: 17,500 €/year

2. Machine learning for human monitoring and activity recognition – Istituto Italiano di Tecnologia

Curriculum: Industry 4.0

Hosting Institution
Istituto Italiano di Tecnologia

Department:
Human-Robot Interfaces and Interaction

Tutor
Arash Ajoudani

Description
This PhD project will explore the application of machine learning for human monitoring and activity recognition using video data. The goal is to develop robust and efficient algorithms that can accurately analyze and classify human behaviors in video footage. The specific objectives will include:
Investigating state-of-the-art deep learning architectures for human activity recognition (HAR) in videos.
Developing novel techniques for handling challenges in video-based HAR, such as background clutter, occlusions, and varying viewpoints.
Exploring methods for real-time or low-latency activity recognition for applications requiring immediate response.
Addressing privacy concerns associated with video surveillance and developing methods for anonymizing or obfuscating human identities in video data.
Implementing and evaluating the developed algorithms on publicly available benchmark datasets and potentially real-world video data.

Requirements
The successful candidate must have an MSc degree with a strong background in Machine Learning and/or computer vision.
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

- Lagomarsino, M., Lorenzini, M., De Momi, E. and Ajoudani, A., 2022. An online framework for cognitive load assessment in industrial tasks. Robotics and Computer-Integrated Manufacturing, 78, p.102380.
- Merlo, Elena, et al. "Automatic Interaction and Activity Recognition from Videos of Human Manual Demonstrations with Application to Anomaly Detection." 2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN). IEEE, 2023

Number of positions available: 1

Main Research Site
Center for Robotics and Intelligent Systems (CRIS), IIT, Genova

Contacts
Email: Arash.ajoudani@iit.it

Funding Scheme
This doctorate grant is funded in part by the Italian Institute of Technology and project INAIL VIVA CUP: J53C2400053005

Scholarship Amount:

- Fascia 2: 17,500 €/year

3. Soft Robotics for Archeology – Istituto Italiano di Tecnologia

Curriculum: Industry 4.0

Hosting Institution
Istituto Italiano di Tecnologia

Department:
Soft Robotics for Human Cooperation and Rehabilitation

Tutors
Antonio Bicchi, Manuel G. Catalano, Giorgio Grioli

Description
The AUTOMATA project means to facilitate large-scale, rich, low-cost digitisation campaigns for archaeological finds (pottery and lithics) through an AI-augmented robotic system equipped with sensors. It will quickly and efficiently create 3D models of archaeological finds, enriched with archaeometric data, made freely available online, allowing effective data reuse by researchers and citizens. Our ambition is to create an open-source robotic infrastructure, encompassing both hardware and software components, that is modular, cost-effective, straightforward to deploy, and designed to automate the digitisation and analysis of small-sized artefacts, that can deployed in different archaeological contexts by non-experts.
The successful candidate will apply the paradigms of soft robotics to the development of Human-Robot Cooperation solution for the automatic digitisation and analysis of archaeological artefacts..

Requirements

- An MSc degree in Robotic Engineering, Mechatronic Engineering or closely related fields.
- Good communication skills.
- Ability and willingness to integrate in a multidisciplinary international research group.
- Good knowledge of written and spoken English.
- Knowledge of Matlab, Simulink and ROS is welcome.

References

- Catalano, Manuel G., et al. "Adaptive synergies for the design and control of the Pisa/IIT SoftHand." The International Journal of Robotics Research 33.5 (2014): 768-782.
- Mura, D., Barbarossa, M., Dinuzzi, G., Grioli, G., Caiti, A., & Catalano, M. G. (2018). A soft modular end effector for underwater manipulation: A gentle, adaptable grasp for the ocean depths. IEEE Robotics & Automation Magazine, 25(4), 45-56.
- Angelini, F., Petrocelli, C., Catalano, M. G., Garabini, M., Grioli, G., & Bicchi, A. (2020). SoftHandler: An integrated soft robotic system for handling heterogeneous objects. IEEE Robotics & Automation Magazine, 27(3), 55-72.

Number of positions available: 1

Main Research Site
Center for Robotics and Intelligent Systems (CRIS), IIT, Genova

Contacts

Email: giorgio.grioli@iit.it
Funding Scheme This doctorate grant is funded by the Italian Institute of Technology from fundings coming from the EU project AUTOMATA
Scholarship Amount: ● Fascia 4: 19,500 €/year

4. Implementation of Dual Arm Manipulation for human-robot cooperative operations – Università di Genova

Curriculum: Industry 4.0

Hosting Institution
Università di Genova

Department
DIBRIS

Tutor
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. Between the different approaches to perform Human-Robot Cooperation, Bi-manual or multi-arm manipulation becomes the predominant technique for this type of applications.

The advantages of implementing Bi-manual or Dual arm manipulation (DAM) refers to the ability of transfer the skill of the human entity-operator to the robot in a more intuitive way, and in dual arm coordinated tasks, the use of dual arm manipulation allows to combine the task flexibility and dexterity of serial links, with the stiffness and strength of parallel manipulation while holding objects. (closed chain mechanism)

The PhD project has the goal to implement a dual arm/Bi manual control approach for coordinated tasks, while overcoming the principal issues when performing dual-arm manipulation, such as generating feasible configurations connected through each other (motion planning), internal forces acting while arms are holding objects, manipulators breaking and reinitializing contact with a common object(regrasping), among others.

The experimental scenario is based on a dual-arm robot (sensorized using cameras, tactile and proximity sensors) mounted on a mobile platform for assistive or domestic applications, 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

- Zhang, J., Xu, X., Liu, X., & Zhang, M. (2018, December). Relative dynamic modeling of dual-arm coordination robot. In 2018 IEEE International Conference on Robotics and Biomimetics (ROBIO) (pp. 2045-2050). IEEE.

- Wang, J., Liu, S., Zhang, B., & Yu, C. (2019). Inverse kinematics-based motion planning for dual-arm robot with orientation constraints. International Journal of Advanced Robotic Systems, 16(2), 1729881419836858.
- Xian, Z., Lertkultanon, P., & Pham, Q. C. (2017). Closed-chain manipulation of large objects by multi-arm robotic systems. IEEE Robotics and Automation Letters, 2(4), 1832-1839.

Number of positions available: 1

Main Research Site
DIBRIS – Università di Genova

Contacts
Email: giorgio.cannata@unige.it

Funding Scheme
This doctorate grant is co-funded by Università di Genova and European project HE Sestosenso.

Scholarship Amount:
Fascia 4: 19,500 €/year

5. Advanced integration of perception and navigation systems for unstructured environments in coordination with human beings – Leonardo s.p.a. and University of Genova.

Curriculum: Industry 4.0

Hosting Institution
University of Genoa

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

Tutor(s):
Fulvio Mastrogiovanni
Navvab Kashiri (Leonardo s.p.a.)

Description:

The core focus of this thesis lies on achieving tight integration between perception and navigation functionalities, while also leveraging human-robot collaboration. Current robotic navigation systems primarily rely on localization techniques to determine the robot's position within a pre-mapped environment. This thesis proposes a novel approach that goes beyond simple localization using LiDAR. By integrating perception systems encompassing sensors and cameras, the robot will actively build and maintain a dynamic map of the environment, including both static elements and mobile objects. This real-time map will not only enable self-navigation but also empower the robot to understand and react to its surroundings.

The human element plays a crucial role in this framework. The thesis explores methods for seamless human-robot interaction, allowing humans to guide the robot and provide context about the environment and desired tasks. This collaborative approach can be particularly advantageous when searching for specific objects within the unstructured environment. By leveraging the human's ability to recognize and categorize objects, the robot can refine its search strategy based on real-time data and human input, ultimately achieving faster and more accurate object retrieval.

This research will contribute significantly to the field of human-robot collaboration by:

1. Enhancing robot autonomy and adaptability: Robots will be able to operate effectively in dynamic environments without constant pre-programming.
2. Improving human-robot teamwork: Seamless interaction will enable humans to effectively guide robots and leverage their capabilities.
3. Facilitating real-world applications: The proposed system can be applied in various domains like search and rescue, industrial automation, and assistive technologies.

The successful implementation of this thesis will pave the way for a future where robots seamlessly integrate into our lives, functioning as intelligent collaborators in complex and ever-changing environments.

Requirements:
Applicants are expected to have a background in robotics, mechatronics, computer science and engineering, and related disciplines. They are also expected to be proficient in software design, software development, and control theory. Outstanding candidates have experience in software frameworks for robots, machine learning, knowledge representation and planning for robots, as well as robot motion control. Exceptional candidates have carried out research activities related to task-motion planning.

References:

- E. Merlo, E. Lamon, F. Fusaro, M. Lorenzini, A. Carfì, F. Mastrogiovanni, A. Ajoudani. An ergonomic role allocation framework for dynamic human-robot collaborative tasks. Journa of Manufacturing Systems 67:111-121, April 2023.
- K. Darvish, E. Simetti, F. Mastrogiovanni, G. Casalino. A hierarchical architecture for human robot collaboration processes. IEEE Transactions on Robotics 37(2):567-586, April 2021.

Company name and link (for industrial projects):
Leonardo S.p.A. (www.leonardo.com)

Number of positions available:
1

Main Research Site
Department of Informatics, Bioengineering, Robotics, and Systems Engineering, University of Genoa, Italy.

Contacts:

Prof. Fulvio Mastrogiovanni, email: fulvio.mastrogiovanni@unige.it

Funding Scheme: This doctorate grant is co-funded by **PROGRAMMA REGIONALE FONDO SOCIALE EUROPEO+ 2021-2027 PRIORITÀ 2 - ISTRUZIONE E FORMAZIONE - ESO 4.6 (OS-f) and Leonardo s.p.a..**

Scholarship Amount:
- Fascia 4: 19,500 €/year

6. Cognitive robot architectures based on prediction machine theory – University of Genoa

Curriculum: Industry 4.0

Hosting Institution
University of Genoa

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

Tutor(s):
Fulvio Mastrogiovanni

Description:
Despite recent advancements and achievements, robots still grapple with Moravec's paradox, stating that low-level sensorimotor processes should require a higher effort in computational resources than high-level reasoning activities, because they capitalize on the results yield by the evolutionary process leading to structured and organized bodies. Current robot cognitive architectures worsen Moravec's paradox by emphasizing a separation between the robot's "brain" and its body.

This PhD project aims to explore the use of prediction machine theory, a novel understanding of mammalian brain functionality, in designing a robot cognitive architecture aimed at reducing this "Cartesian" divide. Stemming from the theoretical framework of the free energy principle, prediction machine theory postulates that the mammalian brain acts as a predictor of sensory stimuli within each sensorimotor loop, from higher-level cognitive processes such as the various forms of reasoning, up to forms of morphological computation distributed in the body as it physically interacts with the surrounding environment.

The PhD student will analyze existing literature on robot cognitive architectures, and critically identify which principles related to prediction machine theory could inspire the design of next-generation cognitive robot architectures, as well as their implications on the robot body. A reference scenario will be considered, in which a human and a robots must collaborate to reach a common objective (for example, an assembly). In this scenario, the robot should predict a) the physical behavior of the objects in the environment, also as per the consequence of its own actions, and b) possible sequences of (discrete) human actions and (continuous) motions leveraging its observations, the human-robot collaboration "dynamics", and the events occurring in the shared workspace.

The PhD student will delve into a number of topics including: (1) studying robot cognitive architectures and formalizing prediction machine theory, (2) designing predictive models for various sensorimotor loops, (3) developing specific predictors for physical processes and human behaviors in specialized contexts, (4) creating a knowledge representation and prediction framework to ground these models, and (5) implementing and evaluating a novel robot cognitive architecture based on prediction machine theory in real-world use cases, specifically pertaining to human-robot collaboration.

Requirements:
Applicants are expected to have a background in robotics, mechatronics, computer science and engineering, and related disciplines. They are also expected to be proficient in software

design, software development, and control theory. Outstanding candidates have experience in software frameworks for robots, machine learning, knowledge representation and planning for robots, as well as robot motion control. Exceptional candidates have carried out research activities related to human behaviour modelling.

References:

2. K. Friston. The free-energy principle: a unified brain theory? Nature Reviews Neuroscience 11(2):127-138, 2010.
3. L. Seminara, S. Dosen, F. Mastrogiovanni, M. Bianchi, S. Watt, P. Beckerle, T. Nanayakkara, K. Drewing, A. Moscatelli, R. L. Klatzky, G. E. Loeb. A hierarchical sensorimotor control framework for human-in-the-loop robotic hands. Science Robotics 8 (78), eadd5434, 2023.
4. G. Pezzulo, T. Parr, K. Friston. Active inference as a theory of sentient behavior. Biological Psychology. 108741, 2024.

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

Number of positions available:
1

Main Research Site
Department of Informatics, Bioengineering, Robotics, and Systems Engineering, University of Genoa, Italy.

Contacts:

Prof. Fulvio Mastrogiovanni, email: fulvio.mastrogiovanni@unige.it

Funding Scheme: This doctorate grant is [fully] funded by … .

In case of **PNRR funding scheme (if applicable):**

- PNRR program DM-629

Scholarship Amount:

- Fascia 2: 17,500 €/year

7. Safe human-robot collaboration for manipulation - Sapienza Università di Roma (UNIROMA1)

Curriculum: Industry 4.0

Hosting Institution
Sapienza University of Rome

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

Tutor(s):
Alessandro De Luca

Description:

In the context of integration between advanced IT techniques and automation of production processes (Industry 4.0), the theme of this doctorate concerns the introduction of collaborative robotic systems for the semi-automatic assembly and testing of aerospace components and devices, in a joint program between Sapienza University of Rome and Thales Alenia Space Italia. Starting from an analysis of the existing assembly and test procedures, which are currently carried out manually, activities will be identified that can be performed, under premises of efficiency and safety, in a collaborative mode between operator and robot. Based on the corresponding specifications, the sensory system needed for coexistence and collaboration will be designed, together with the supervisory system for controlling motion and exchanged forces during physical interaction, and the associated human-machine interface. Research topics to be addressed include, but are not limited to:
Collision/contact detection and safe robot reaction
Task preserving reaction strategies in the presence of kinematic redundancy
Optimal placement of vision/depth sensors for cell monitoring
Sensorless estimation of contact forces
Human motion/intention prediction
Force, impedance, admittance control for generic contact locations along the robot
Learning schemes for repetitive collaborative tasks, under largely uncertain dynamics
The goal is the creation of a prototype of a flexible cell for the assembly of small satellites, in which the most advanced research results in collaborative robotics will be implemented.

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:

- D. Zurlo, T. Heitmann, M. Morlock, and A. De Luca (2023). Collision detection and contact point estimation using virtual joint torque sensing applied to a cobot. Proc. IEEE Int. Conf. on Robotics and Automation, 7533-7539. DOI:10.1109/ICRA48891.2023.10160661
- M. Khatib, K. Al Khudir, and A. De Luca (2021). Human-robot contactless collaboration with mixed reality interface. Robotics and Computer-Integrated Manufacturing, 67, 102030. DOI:10.1016/j.rcim.2019.101846

- M. Iskandar, O. Eiberger, A. Albu-Schäffer, A. De Luca, and A. Dietrich (2021). Collision detection and localization for the DLR SARA robot with sensing redundancy. Proc. IEEE Int. Conf. on Robotics and Automation, 3111-3117. DOI:10.1109/ICRA48506.2021.9561677
- E. Mariotti, E. Magrini, and A. De Luca (2019). Admittance control for human-robot interaction using an industrial robot equipped with a F/T sensor. Proc. IEEE Int. Conf. on Robotics and Automation, 6130-6136. DOI:10.1109/ICRA.2019.879365
- C. Gaz, E. Magrini, and A. De Luca (2018). A model-based residual approach for human-robot collaboration during manual polishing operations. Mechatronics, 55, 234-247. DOI:10.1016/j.mechatronics.2018.02.014
- 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
- E. Magrini and A. De Luca (2017). Human-robot coexistence and contact handling with redundant robots. Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, 4611-4617. DOI:10.1109/IROS.2017.8206331
- E. Magrini and A. De Luca (2016). Hybrid force/velocity control for physical human-robot collaboration tasks. Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, 857-863. DOI:10.1109/IROS.2016.7759151
- F. Flacco, T. Kröger, A. De Luca, and O. Khatib (2015). A depth space approach for evaluating distance to objects -- with application to human-robot collision avoidance. J. of Intelligent & Robotic Systems, 80, 7-22. DOI:10.1007/s10846-014-0146-2

- Number of positions available: 1

Number of positions available:
1

Main Research Site
DIAG Robotics Laboratory, Sapienza University of Rome
Thales Alenia Space Italia (TASI), Rome

Contacts:
Email: a.deluca@uniroma1.it

Funding Scheme:
- This doctorate grant is funded in approximately equal parts by
- DIAG funds at Sapienza University of Rome (scientific responsabile: Prof. Alessandro De Luca).
- Thales Alenia Space Italia (TASI)

Scholarship Amount:
- Fascia 1: 16,500€/year

8. Quadrupedal Locomotion and Navigation on Unstructured Scenarios – Leonardo s.p.a. and University of Genova

Curriculum: Industry 4.0

Hosting Institution
University of Genova

Department:
DIBRIS

Tutor(s):
Giorgio Cannata
Navvab Kashiri (Leonardo s.p.a.)

Description:
The proposed framework integrates these techniques to achieve two key functionalities:

1. Whole-Body Balancing Controller: The framework leverages centroidal dynamics to design a controller that maintains the robot's balance despite external disturbances or uneven terrain. This controller will regulate the robot's COM trajectory, ensuring stability during various gaits like walking, trotting, or even crawling.
2. Effective and Robust Gait Generator: MPC is employed to generate optimal gaits for efficient locomotion. The MPC controller takes into account the desired locomotion task, real-time sensor data (e.g., joint positions, torques), and the environmental conditions.

Requirements:
Applicants are expected to have a background in robotics, mechatronics, computer science and engineering, and related disciplines. They are also expected to be proficient in software design, software development, and dynamic control.

References:

- Zhao, X., You, Y., Laurenzi, A., Kashiri, N., Tsagarakis, N. "Locomotion Adaptation in Heavy Payload Transportation Tasks with the Quadruped Robot CENTAURO" (2021) Proceedings - IEEE International Conference on Robotics and Automation, 2021-May, pp. 5028-5034.
- Kashiri, N., Baccelliere, L., Muratore, L., Laurenzi, A., Ren, Z., Hoffman, E.M., Kamedula, M., Rigano, G.F., Malzahn, J., Cordasco, S., Guria, P., Margan, A., Tsagarakis, N.G. "CENTAURO: A hybrid locomotion and high power resilient manipulation platform", (2019) IEEE Robotics and Automation Letters, 4 (2), art. no. 8630605, pp. 1595-1602.

Company name and link (for industrial projects):
Leonardo S.p.A. (www.leonardo.com)

Number of positions available:
1

Main Research Site
Department of Informatics, Bioengineering, Robotics, and Systems Engineering, University of Genoa, Italy.

Contacts: Prof. Giorgio Cannata, email: giorgio.cannata@unige.it Dr. Navvab Kashiri, email: navvab.kashiri@leonardo.com
Funding Scheme: This doctorate grant is co-funded by **PROGRAMMA REGIONALE FONDO SOCIALE EUROPEO+ 2021-2027 PRIORITÀ 2 - ISTRUZIONE E FORMAZIONE - ESO 4.6 (OS-f) and Leonardo s.p.a..**
Scolarship Amount: • Fascia 4: 19,500 €/year

9. Human/Robot collaboration in cooperative assembly tasks – Leonardo s.p.a. and University of Genova

Curriculum: Industry 4.0

Hosting Institution
University of Genova

Department:
DIBRIS

Tutor(s):
Giorgio Cannata
Navvab Kashiri (Leonardo s.p.a.)

Description:
The framework integrates the four key control methods:

1. Position Control: Ensures precise robot movement for tasks requiring high accuracy.
2. Force Control: Enables robots to interact with the environment and human partners with controlled forces.
3. Impedance Control: Combines position and force control, allowing robots to adapt to varying contact forces during assembly.
4. Admittance Control: Focuses on the robot's dynamic response to external forces, ideal for tasks requiring compliance.

Requirements:
Applicants are expected to have a background in robotics, mechatronics, computer science and engineering, and related disciplines. They are also expected to be proficient in software design, software development, and dynamic control.

References:

- Romiti, E., Malzahn, J., Kashiri, N., Iacobelli, F., Ruzzon, M., Laurenzi, A., Hoffman, E.M., Muratore, L., Margan, A., Baccelliere, L., Cordasco, S., Tsagarakis, N. "Toward a Plug-and-Work Reconfigurable Cobot (2022) IEEE/ASME Transactions on Mechatronics, 27 (5), pp. 3219-3231.
- Muratore, L., Laurenzi, A., Hoffman, E.M., Baccelliere, L., Kashiri, N., Caldwell, D.G., Tsagarakis, N.G. "Enhanced Tele-interaction in Unknown Environments Using Semi-Autonomous Motion and Impedance Regulation Principles", (2018) Proceedings - IEEE International Conference on Robotics and Automation, art. no. 8460559, pp. 5813-5820.

Company name and link (for industrial projects):
Leonardo S.p.A. (www.leonardo.com)

Number of positions available:
1

Main Research Site
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Prof. Giorgio Cannata, email: giorgio.cannata@unige.it

Dr. Navvab Kashiri, email: navvab.kashiri@leonardo.com
Funding Scheme: This doctorate grant is co-funded by **PROGRAMMA REGIONALE FONDO SOCIALE EUROPEO+ 2021-2027 PRIORITÀ 2 - ISTRUZIONE E FORMAZIONE - ESO 4.6 (OS-f) and Leonardo s.p.a..**
Scolarship Amount: • Fascia 4: 19,500 €/year

10. Research Theme Title: KNOWSUM: Knowledge Summarization with Cognitive Science, Artificial Intelligence and Knowledge Graphs

Curriculum: Industry 4.0

Hosting Institution
University of Trento

Department:
DIPSCO

Tutor(s):
Massimo Stella

Description:
The KNOWSUM project aims to design, develop, and test an artificial intelligence (AI) that summarizes the content of conversations of interest to the Public Administration (such as board of directors' dialogues, minute taking, interrogations, meetings, parliamentary debates, and others). Unlike "black-box" approaches with Large Language Models (LLMs), the PhD candidate involved in KNOWSUM will create a methodology based on solid foundations of cognitive theories of information processing (e.g., the semantic processing model with network activation by Collins and Loftus) and integrate them with new techniques of interpretable natural language processing (NLP) like knowledge graphs (Google 2012). In addition to this synthesis, the PhD project also aims to test the devised methodology on real dialogues, integrating them with an interpretable prompting system (via LLM), so that the results obtained from an interpretable knowledge graph can be explored with structured natural language (prompts) requests from the user.
The test will be conducted with the support of a leading company in the Italian AI scene and with data relating to the Public Administration. The impact of the proposed research is related to accelerating digital transformation processes: The AI tool developed in this PhD will have a dual significance: (i) cognitive and research, to test how specific cognitive models can be used to identify key information and syntactic dependencies in knowledge graphs of transcriptions, and (ii) digital transformation, using the acquired knowledge and the AI tool to develop new ICT methodologies, tested and thus applicable in a PA context.

Requirements:
The PhD candidate involved in KNOWSUM will follow a research path focused on the computational analysis of large volumes of text from a psychological and cognitive perspective (e.g., spreading activation, theory of semantic networks, distributional vector spaces, cognitive biases). By also addressing the study of the functioning of interpretable AI models and Large Language Models, the resource will be able to explore possible new perspectives for using these technologies, combined together in an interpretable and scalable way. This will also occur in a corporate context and of interest to Public Administrations (PAs), with data provided by Cedat85, a leader in the Italian customer care sector for speech synthesis and data analysis. With a synergy of theoretical, computational, and organizational aspects, the resource will aim to: (i) train and become an expert in cognitive data science and AI, and (ii) develop new text synthesis techniques in the PA sector in an interpretable way in light of innovative ICT

technologies, such as knowledge graphs and Large Language Models. In both goals, the resource will benefit from the educational paths offered by UniGe (Intelligent Machines) and UniTrento (Cognitive Sciences), the PA data, and the technological and educational know-how of Cedat85, as well as the experience of international experts in the field of computational psychology and data analysis. The training will also be aimed at applying AI technologies to traditional transcription systems, with consequent optimization of information acquisition processes for innovative PA contexts, where the synthesis of hours of meetings can translate into shortening decision-making times, improving the productivity of public actions, and searching for key information for institutional planning with reduced cognitive biases.

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- Stella, M., & Kenett, Y. N. (2022). Knowledge modelling and learning through cognitive networks. *Big Data and Cognitive Computing*, *6*(2), 53.

Company name and link (for industrial projects):
Cedat85 (www.cedat85.com)

Number of positions available:
1

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- Fascia 1: 16,500 €/year