

# SIDRA Summer School, Bertinoro

## Intelligent Collaborative Robotics

July 18–20, 2019

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**Aim:** Recent technological advances in the design of robotic platforms enabled the implementation of various control modalities for interactions with humans in different environments. An important application area for the integration of robots with such advanced interaction capabilities is human–robot collaboration. The research community’s recent surge of interest in this area has been devoted to the implementation of methodologies to achieve intuitive and seamless human–robot intelligent interactions, by incorporating their complementary capabilities.

The course aims at giving a broad overview on human-robot interaction and specifically on how collaborative robots can be employed safely, intelligently, and adaptively, with humans. Modelling and control of robotic manipulators in interaction with the environment, and specifically with the human, will be extensively discussed with an eye to the safety standards applicable to human-robot collaboration. Algorithms for cognitive interaction between the robot and the human will be presented as well, leveraging machine learning techniques to fully implement the new paradigm of intelligent collaborative robotics.

**References:** Lecture notes will be provided covering most of the topics. Additional references include:

1. A. Ajoudani, A.M. Zanchettin, S. Ivaldi, A. Albu-Schaeffer, K. Kosuge, O. Khatib  
*"Progress and prospects of the human–robot collaboration"*, Autonomous Robots, vol. 42(5), pp. 957-975, June 2018.
2. A. M. Zanchettin, A. Casalino, L. Piroddi, Rocco  
*"Prediction of human activity patterns for human-robot collaborative assembly tasks"*, IEEE Transactions on Industrial Informatics, available online, DOI: 10.1109/TII.2018.2882741
3. A. M. Zanchettin, P. Rocco, R. Rossi, S. Chiappa  
*"Towards an optimal avoidance strategy for collaborative robots"*, Robotics and Computer Integrated Manufacturing, Vol. 59, pp. 47-55, October 2019.
4. M. Ragaglia, A.M. Zanchettin, P. Rocco  
*"Trajectory generation algorithm for safe human-robot collaboration based on multiple depth sensor measurements"*, Mechatronics, Vol. 55, pp. 267-281, November 2018
5. A.M. Zanchettin, P. Rocco  
*"Probabilistic inference of human arm reaching target for effective human-robot collaboration"*, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2017), Vancouver (Canada), September 2017, pp. 6595 - 6600.
6. A.M. Zanchettin, N.M. Ceriani, P. Rocco, H. Ding, B. Matthias  
*"Safety in human-robot collaborative manufacturing environments: metrics and control"*, IEEE Transactions on

- Automation Science and Engineering, Vol. 13, No. 2, pp. 882-893, April 2016
7. A.M. Zanchettin, L. Bascetta, P. Rocco,  
“Achieving humanlike motion: resolving redundancy for anthropomorphic industrial manipulators”, IEEE Robotics and Automation Magazine, Vol. 20, No. 4, pp. 131-138, December 2013
  8. B. Lacevic, P. Rocco, A.M. Zanchettin  
“Safety assessment and control of robotic manipulators using danger field”, IEEE Transactions on Robotics, Vol. 29, No. 5, pp. 1257-1270, October 2013
  9. B. Siciliano, L. Sciavicco, L. Villani, G. Oriolo  
“Robotics: Modelling, Planning and Control”, 3rd Ed., Springer, 2009

**Course prerequisites:** Background (graduate-level) on linear algebra, geometry, mechanics, and control, is required.

**Course Syllabus and Schedule:**

*Thursday, July 18*

09:00-10:30: Review of robotics: introduction on robotics, direct, inverse and differential kinematics

11:00-12:30: Review of robotics: dynamics, motion planning

15:00-16:30: Collaborative robotics: introduction, motivations, classifications, applications, modes of collaboration.

17:00-18:30: Hand guiding: force reconstruction, admittance/impedance control, virtual fixtures

*Friday, July 19*

09:00-10:30: Speed and separation monitoring: sensors, methods for velocity scaling, danger field

11:00-12:30: Power and force limitations: contact modelling and classification, energy-related control algorithms

15:00-16:30: Intelligent collaboration: introduction, classification and prediction algorithms

17:00-18:30: Intelligent collaboration: application to selected problems (human walking, reaching target classification, human action prediction)

*Saturday, July 20*

09:00-10:30: Intelligent collaboration: scheduling of robot actions based on classification and prediction of human actions

11:00-12:30: A case study: an industrially relevant case study in intelligent collaborative robotics