



UNIVERSITÀ DI PISA
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE
Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

“Iterative Learning Control Theory & Applications - An Alternative Approach to Exploit Data while Providing Formal Certificates”

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With Franco Angelini and Michele Pierallini

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Short Abstract:

The availability of an unprecedented level of computational power and data – both real and synthetic - opens a whole new range of possibilities in several fields. This is strongly impacting the way to plan and control the behavior of systems. The mainstream approach apply supervised/unsupervised machine learning algorithms for which it is hard to provide formal certificates on important properties like convergence and stability.

This course presents an alternative approach able to provide such guarantees leveraging upon a minimalistic model knowledge: the iterative learning control.

First the theoretical foundations of the method will be covered for linear and nonlinear discrete and continuous systems, hence an overview of recent applications pertaining to the robotic field will be given. Finally theoretical open problems will be discussed.

Course Contents in brief:

1. Introduction (0.5 h)
2. Iterative Learning Control (ILC) for linear systems (3 h)
3. ILC for nonlinear systems (3.5 h)
4. From input-state to input-output (3.5 h)
5. Feed-forward and Feedback ILC (3.5 h)
6. Matlab Implementation (3.5 h)
7. Examples (3.5 h)
8. Open Problems in ILC Theory and Applications (3.5 h)

Total # of hours: 24

References:

Ahn, Hyo-Sung, Kevin L. Moore, and YangQuan Chen. Iterative learning control: robustness and monotonic convergence for interval systems. London: Springer, 2007.

Chen, Yangquan, and Changyun Wen, eds. Iterative learning control: convergence, robustness and applications. London: Springer London, 1999.

Bristow, Douglas A., Marina Tharayil, and Andrew G. Alleyne. "A survey of iterative learning control." IEEE control systems magazine 26.3 (2006): 96-114.

CV of the Lecturer

Manolo Garabini graduated in Mechanical Engineering and received the Ph.D. degree in Robotics from the University of Pisa where he is currently employed as Associate Professor. His main research interests are in the design, planning and control of soft and adaptive robots, from single joints, to end-effectors (hands, grippers, feet), to complex multi-d.o.f. systems. A part of his activity has been devoted to theoretically demonstrate the effectiveness of soft and adaptive robots in high performance, high efficiency and resilient tasks via analytical and numerical optimization tools. He contributed to the realization of modular Variable Stiffness Actuators: the VSA-Cube. He contributed in the design of the joints and the lower body of the humanoid robot WALK-MAN and took part at the DARPA Robotics Challenge and at a field test in Amatrice, Italy after a disastrous earthquake event. Recently he contributed to the development of effective learning-based algorithms to control the motion of flexible joint and soft robots. Currently he is the local Principal Investigator in the European Research Project THING, within the H2020 framework, for the University of Pisa, the coordinator of the project Dysturbance, subproject of the European Research Project Eurobench, within the H2020 framework, and the coordinator of the H2020 project Natural Intelligence.

Franco Angelini received the B.S. degree in computer engineering in 2013 and M.S. degree (cum laude) in automation and robotics engineering in 2016 from the University of Pisa, Pisa, Italy. University of Pisa granted him also a Ph.D. degree (cum laude) in robotics in 2020. Franco currently has a research fellowship at the Research Center "Enrico Piaggio", Pisa. His main research interests are control of soft robotic systems, grasping and impedance planning.

Michele Pierallini received the B.S. degree in biomedical engineering in 2017 and M.S. degree (cum laude) in automation and robotics engineering in 2020 from the University of Pisa, Pisa, Italy, where he is currently working toward the Ph.D. degree in robotics at the Research Center "Enrico Piaggio." His current research focuses on the control of soft robotic systems and iterative learning control.

Room Meeting room, ground floor, Via G. Caruso 16 - 56122 – Pisa.

Schedule Monday 29, July – Friday 2 August 2024

Mon	Tue	Wed	Thu	Fri
	8:30	8:30	8:30	8:30
	10:30	10:30	10:30	10:30
	Break	Break	Break	Break
	11:00	11:00	11:00	11:00
	12:30	12:30	12:30	12:30
Lunch				
13:30	13:30	Lab Visit	13:30	
15:30	15:30		15:30	
Break	Break		Break	
16:00	16:00		16:00	
	17:30		17:30	