



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

Doctoral Course

**“CRASH COURSE ON MODELING AND CONTROL OF CONTINUUM SOFT ROBOTS”**

Cosimo Della Santina

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*Robotics and Mechatronics Institute, German Aerospace Center, Wessling, Germany*

**Short Abstract:** Humans and other animals outperform traditional robots in terms of reliability and efficiency, largely due to their unique physical characteristics. They have elastic tendons, ligaments, and muscles, which allow robust interaction with the environment and dynamic task execution. In contrast, classic robots are often stiff and heavy. Accordingly, researchers in robotics have shifted from focusing on rigidity to incorporating lightweight and compliant structures. Drawing from natural examples, robots now include elastic and soft components, leading to the development of flexible joint and link robots and articulated and continuum soft robots. These latter types are composed entirely of deformable elements, making them akin to invertebrate animals. This proliferation of new robotic designs creates the challenge of developing effective control strategies for managing a nonlinear mechanical system with numerous degrees of freedom (DOFs) and a high degree of underactuation. This course will introduce this control challenge, especially focusing on continuum soft robots, review established findings, highlight recent advancements, and explore open issues in the field.

**Course Contents in brief:**

1. Introduction (2h)
2. Refreshers on model-based control and control of rigid robots (2h)
3. Modeling of continuum soft robots (4h)
4. Shape control (4h)
5. Task space control (2h)
6. Other control challenges in CSRs' control (2h)

**Total # of hours:** 16

**References:**

Della Santina, Cosimo, Christian Duriez, and Daniela Rus. "Model-Based Control of Soft Robots: A Survey of the State of the Art and Open Challenges." *IEEE Control Systems Magazine* 43.3 (2023): 30-65.

Della Santina, Cosimo, Manuel Catalano, and Antonio Bicchi. "Soft robots." Encyclopedia of Robotics 489 (2021).

Della Santina, Cosimo. "Flexible manipulators." Encyclopedia of Robotics 20 (2021).

### CV of the Lecturer

Cosimo Della Santina is an Assistant Professor at TU Delft and a Guest Scientist at the German Aerospace Institute (DLR). He earned his Ph.D. in robotics (cum laude, 2019) from the University of Pisa. He was a visiting Ph.D. student and a postdoc (2017 to 2019) at MIT's Computer Science and Artificial Intelligence Laboratory. Subsequently, he held a senior postdoc position (2020) and served as a guest lecturer (2021) at the Department of Informatics at the Technical University of Munich (TUM). Cosimo has been awarded the euRobotics Georges Giralt Ph.D. Award (2020), the "Fabrizio Flacco" Young Author Award from I-RAS (2019), and was a finalist for the European Embedded Control Institute Ph.D. award (2020). In 2023, he received the IEEE RAS Early Academic Career Award in Robotics and Automation. He is Principal Investigator for European and Dutch projects, such as H2020 Natural Intelligence, EH EMERGE, and one of the Dutch Agrifood Nxtgen Hightech subprojects. He is an NWO VENI laureate and co-directs the Delft AI lab SELF. Cosimo leads the Phi-Lab at TU Delft, focusing on the study of embodied and disembodied intelligence in physical systems, with an emphasis on elastic and soft robots.

**Dates, Room, and Days** Oct. 7 Oct 9, 2024, Department of Information Engineering

Mo Oct. 7	Tue Oct. 8	Wed Oct. 9
9:00	9:00	9:00
10:30	10:30	10:30
Break	Break	Break
11:00	11:00	11:00
12:30	12:30	12:30
Lunch		
14:00	14:00	14:00
15:30	15:30	15:30
Break	Break	
16:00	16:00	
17:15	17:15	