



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

Doctoral Course

“Tactile Sensors for Robotics and Advanced Human Machine Interaction”

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Short Abstract:

Tactile sensors play a crucial role not only in robotics, e.g. to advance autonomous robotic manipulation capabilities and telerobotics, but also in a wide range of fields encompassing human-machine interaction. This course aims at providing an introduction to the main types of tactile sensors, with special focus on force and optical tactile sensors. The course will introduce the physical characteristics and mathematical models for the usage of these sensors, alongside the main algorithms used to extract tactile information, both model-based and data-driven. The main applications in robotics, advanced human-machine interaction and biomedical engineering will be revised. The course will be complemented by hands-on-demos with the main types of tactile sensors.

Course Contents in brief:

- Introduction to Tactile Sensors
- Intrinsic vs. Extrinsic Tactile Sensing
- Force-based Sensing: characteristics, models, optimal design and algorithms
- Extrinsic sensing: overview and examples
- Optical tactile sensors
- Model-based and data-driven approaches
- Applications
- Hands-on-Demos

Total # of hours of lecture: 16

References:

- [1] "Force and Tactile Sensors" – *Handbook of Robotics*, Springer 2016
 - [2] N. F. Lepora, "Soft Biomimetic Optical Tactile Sensing With the TacTip: A Review," in *IEEE Sensors Journal*, vol. 21, no. 19, pp. 21131-21143, 1 Oct.1, 2021
 - [3] Bicchi, Antonio, J. Kenneth Salisbury, and David L. Brock. "Contact sensing from force measurements." *The International Journal of Robotics Research* 12.3 (1993): 249-262.
 - [4] Kang et al. "Shape optimization of a mechanically decoupled six-axis force/torque sensor". *Sensors and Actuators A: Physical* 209 (2014): 41-51, 2014
 - [5] G. Pagnanelli, L. Zinelli, N. Lepora, M. Catalano, A. Bicchi and M. Bianchi, "Integrating HumanLike Impedance Regulation and Model-Based Approaches for Compliance Discrimination via Biomimetic Optical Tactile Sensors," in *IEEE Transactions on Robotics*, vol. 41, pp. 857-870, 2025
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CV of the Teacher

Matteo Bianchi is currently an Associate Professor at the Department of Information Engineering (DII) and the Bioengineering and Robotics Research Centre "E. Piaggio" of the Università di Pisa. From 2015 to 2023 he was a clinical research affiliate at Mayo Clinic (Rochester, USA). He served as co-Chair of the RAS Technical Committee on Robot Hands, Grasping and Manipulation (2017- 2022) and as Vice-Chair for Information and Dissemination of the RAS Technical Committee on Haptics (2018-2021). From 2021, he is also the Vice-Coordinator of the MSc in Robotics and Automation Engineering at the University of Pisa. From January to June 2011, he worked as a visiting student at the Laboratory for Computational Sensing and Robotics at Johns Hopkins University, Baltimore, USA. He acts as the Principal Investigator of national and EU grants, and research contracts with companies in the field of human-machine interaction. He is author or co-author of more than 150 peer-reviewed contributions and serves as member of the editorial/organizing board of international conferences and journals. His research interests include haptic interface and sensor design, control and validation with applications in virtual reality, robotics/medical robotics (robotassisted minimally invasive surgery and prosthetics), tele-robotics, rehabilitation and assistive robotics; human and robotic hands: optimal sensing and control; psycho-physics and mathematical modeling of the sense of touch and human manipulation; human inspired control of soft robots; machine learning for human and robot manipulation. He is editor of the book "Human and Robot Hands", Springer International Publishing. He is the recipient of several national and international awards and a member of the IEEE.

Final Exam: Multiple choice test

Room and Schedule

Room: *Aula Riunioni del Dipartimento di Ingegneria dell'Informazione, Via G. Caruso 16, Pisa – Ground Floor*

Schedule

14/09/2026 9-13

16/09/2026 9-13

17/09/2026 9-13

18/09/2026 9-13

The course is in the framework of the educational activities of IEEE Student Branch at the University of Pisa

