UNIVERSITÀ DI PISA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Dottorato di Ricerca in Ingegneria dell'Informazione

Doctoral Course

"Bilateral Telerobotics: Challenges, Perspectives and Applications"

Prof. Matteo Bianchi
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Short Abstract:

Bilateral teleoperation (BT) enables to control remotely located mechatronic and robotic systems, while enabling the human operator to experience the remote environment as if directly encountered. BT is of paramount importance for different research areas, including communication, informatics, robotics and bioengineering, among the others. Despite its importance, BT comes with several challenges, the main is to guarantee the stability of the teleoperator loop. In this course, we will review the key ingredients of BT mediated through haptic interfaces and robotic systems. We will move from the characteristics of haptic interfaces and discuss the main control architectures and techniques to ensure stability despite the communication delays and the interaction with stiff environments. We will finally present possible application scenarios and presents hands-on-demos in virtual reality environments.

Course Contents in brief:

- Introduction to Bilateral Teleoperation and Telerobotics
- Haptic Interfaces for Bilateral Teleoperation
- Stability vs Transparency
- Two port framework and passivity techniques
- Wave variables to handle communication delays
- Case study: virtual reality environments
- Review of main applications and hands-on-demos

Total # of hours of lecture: 16

References:

[1] “Telerobotics” – *Handbook of Robotics*, Springer 2016

[2] “Haptics” – *Handbook of Robotics*, Springer 2016

[3] G. Niemeyer, J.-J.E. Slotine: “Telemanipulation with time delays”, *Int. J. Robot. Res*, (2004)

[4] A. van der Schaft- “L2-gain and passivity techniques in nonlinear control”, *Springer Verlag*, 2000

[5] M .Franken, S. Stramigioli, S. Misra, C. Secchi, and A. Macchelli, “Bilateral telemanipulation with time delays: a two-layer approach combining passivity and transparency,” *IEEE Transactions on Robotics*, vol. 27, no. 4, pp. 741–756, 2011]

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

27/07/2026

28/07/2026

29/07/2026

30/07/2026

h 09:00 - 13:00

The course is in the framework of the educational activities of IEEE Student Branch at the University of Pisa	IEEE STUDENT BRANCH – UNIVERSITY OF PISA