UNIVERSITÀ DI PISA

**DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE**

**Dottorato di Ricerca in Ingegneria dell'Informazione**

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Doctoral Course

**"Introduction to Haptics and Haptic Interfaces"**

Prof. Matteo Bianchi
*Department of Information Engineering, University of Pisa (Italy)*
*Research Center "Enrico Piaggio", University of Pisa (Italy)*

**Short Abstract:** Haptics, i.e. the science of touch, represents a vibrating, multi-disciplinary research topic, which crosses the boundaries between neuroscience, psychophysics, robotics and engineering. While in the neuro-scientific community the main focus of haptics is the study of neural and perceptual mechanisms of human tactual sensing, under a technological point of view it aims at suitably replicating such mechanisms through artificial systems (namely haptic interfaces) for human-machine interaction. In this course, we will review the main concepts underlying human touch perception, and how they can be applied to the design of haptic devices and sensors to render and sense, respectively, different types of touch-related information. We will describe the principal components of the mechatronic architecture of these systems, their main application fields and the related issues e.g. concerning control and stability. We will also analyze wearable haptic systems and discuss the role of affective touch, i.e. the emotional component of touch, for the design of a novel generation of interfaces for human robot communication.

**Course Contents in brief:**

- **Introduction to Haptics: from Human Touch to Artificial Touch**
  - Principles of biological touch and mathematical modelling of human tactual sensing. Artificial systems: kinaesthetic devices, tactile displays, and tactile/force sensors – general overview
- **Haptic Devices: Kinaesthetic Devices and Tactile Displays**
  - Haptic Devices: Application Areas
  - Device Architecture; Control Aspects (Tele-Operation and Virtual/Augmented Reality Environments); Haptic Rendering
  - Softness Displays and Texture Rendering (Tool-Mediated Texture Rendering; Surface Haptics)
- **Ungrounded -Wearable Haptics and Affective Haptics**
- **Real-Scenario Applications for tactile/force sensing and haptic rendering**

**Total # of hours of lecture**: 20

**References:**

[1] Matteo Bianchi. “Haptic Devices”. In: *Wiley Encyclopedia of Electrical and Electronics Engineering*. Published Online: 16 Nov 2016.

[2] Hannaford, Blake, and Allison M. Okamura. "Haptics." *Springer Handbook of Robotics*. Springer, Cham, 2016. 1063-1084.

[3] Niemeyer, Günter, et al. "Telerobotics." *Springer Handbook of Robotics*. Springer, Cham, 2016. 1085-1108.

[4] M. Bianchi. “A Fabric-based Approach for Wearable Haptics”. In: *Electronics - Special Issue on Wearable Electronics and Embedded Computing Systems for Biomedical Applications*. 5(3), 44, 2016. doi: 10.3390/electronics5030044

[5] C. Pacchierotti, S. Sinclair, M. Solazzi, A. Frisoli, V. Hayward, D. Prattichizzo. “Wearable Haptic Systems for the Fingertip and the Hand: Taxonomy, Review, and Perspectives”. *IEEE Transactions on Haptics*, 10(4):580-600, October 2017

[6] E. Battaglia, M. Bianchi, A. Altobelli, G. Grioli, M.G. Catalano, A. Serio, M. Santello, and A. Bicchi. “ThimbleSense: a fingertip-wearable tactile sensor for grasp analysis”. In: *IEEE Transactions on Haptics*. 9(1): 121-133, 2016.

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**CV of the Teacher**

**BIANCHI, Matteo**, M. Eng, Ph.D. [Scopus ID: 57202798446]

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I have been working in the fields of haptics and robotics since the beginning of my PhD studies. The starting point of my research has always been the investigation and modelling of human behavior, with special focus on the haptic channel. The results of this investigation have then guided me to develop haptic interfaces and sensing systems for human and robotic hands, which have contributed to go beyond the state of the art in the field of human-robot interaction with haptic feedback, and wearable haptics. For the latter, I proposed an innovative fabric-based approach for system design described in a monographic publication. For these reasons, my research is strongly interdisciplinary and, as such, it has been published in the top journals across the disciplines of neuroscience (Current Biology, Physics of Life Rev., elife, Psychophysiology), medical and bio-engineering (Nature Sci. Reports, Jour. of neuroeng. and rehab, IEEE Trans. on Biomedical Eng.), robotics (Int. Jour. of Robotics Research, IEEE Trans. on Robotics, IEEE Robotics & Autom. Magazine, IEEE Robotics and Autom. Letters), haptics (IEEE Trans. on Haptics). Moreover, my research findings have also received IP protection and possible translations in low-cost mass products, e.g. for entertainment, are also envisaged. My experience in haptics and its applications to the fields of assistive robotics, prosthetics and advanced human-machine interaction has also matured during my active participation in numerous trans-national research projects, and as PI of EU-funded and international collaborative grants as well as of contracts with world-leading companies (funds > 1.2 M€). My reputation on the fundamental areas of human touch modelling, haptic feedback and sensing system design for humans and robots is confirmed by several international awards (e.g. IEEE Haptics Symposium Best Paper Award, Eurohaptics Best Poster Award, IROS JTCF Novel Tech. Award), by my elevation to the role of Co-Chair of the IEEE RAS Technical Committee (TC) on Robotic Hands, Grasping and Manipulation and Vice-Chair for Information Dissemination of the IEEE RAS TC on Haptics, and by my involvement as a member of the Editorial Board of several leading journals and

conferences in the related fields. I have been also invited to write a contribution on Haptic Devices for the Wiley Encyclopedia of Electrical and Electronics Eng. I have co-edited a book on the mutual inspiration between neuroscience and robotics for advancing both these fields, with special focus on design, control, feedback and sensing systems for human and artificial hands.

**PUBLICATIONS:** 38 papers in peer-reviewed international Journals, 44 in peer-reviewed international Conferences. H-index: 17 (Google Scholar); Number of citations: 918 (Google Scholar).

**SUPERVISION OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS**

2009-present 1 Postdoc, 6 PhD Student,1 Visiting PhD Student, 19 Master Students, 3 Bachelor Students, 1 Visiting Bachelor Student. School of Engineering: Department of Information Eng. & Bioengineering and Robotics Research Center "E. Piaggio", University of Pisa (UNIPI), Italy

**TEACHING ACTIVITIES**

2017–present Teacher, Course-holder. System Theory, School of Eng., Energy Eng., UNIPI, Italy

2017-2018 Teacher. Automatic Controls, School of Eng., Biomedical Eng., UNIPI, Italy

2017-2018 Teacher. Distributed Robotics, School of Eng., Automation and Robotics Eng., UNIPI, Italy

2017 Invited Lecturer, RAS Summer school on Soft Manipulation, Germany

2016 Invited Lecturer, XIII Motor Control Summer School – Int. Society of Motor Control, Israel

**EDUCATION**

June 2012 PhD in Automation, Robotics and Bioengineering

School of Engineering, Bioengineering and Robotics Research Center "E. Piaggio", University of Pisa (UNIPI), Italy

**CURRENT POSITION(S)**

June 2018 Tenure-track Assistant Professor (Italian academic definition: RTD-B)

School of Engineering: Department of Information Engineering & Bioengineering and Robotics Research Center "E. Piaggio", University of Pisa (UNIPI), Italy

Feb. 2014 Research Affiliate Appointment

Mayo Clinic, Rochester – MN, USA

**FELLOWSHIPS AND AWARDS**

2017 IEEE ICUMT Conference: Best Paper in Session Robotics and Best Student Paper Awards

2017 IEEE Worldhaptics: Best Paper Award and Best Student Paper Award Finalist (with two papers, one of these authored by a former PhD student of mine E. Battaglia)

2016 Haptics Symposium 2016 Best Paper Award

2015 Meritorious Service Award for the work as a Reviewer for the IEEE Trans. on Haptics

2015 Best Oral Presentation Award, Automatica.it: Italian Conf. of Researchers in Automation

2015 International Conference on Computer-Aided Engineering: Best Poster Award

2014 Visiting Scholar, SBHSE, Arizona State University

2014 EuroHaptics, Best Poster Award

2013 Georges Giralt PhD Award by EURON: Top 9 European PhD theses in Robotics

2013 Best Oral Presentation Finalist, Automatica.it

2012 IROS 2012 JTCF Novel Technology Best Paper Award
2012 Best Interactive Paper Award, Finalist Automatica.it
2011 Visiting Student, LCSR, The Johns Hopkins University (US)
2010 IEEE Symp. on Haptic Interfaces for Virtual Environments and Teleoperator Systems: Best Paper and Best Paper Award Finalist

2009 Scholarship funded by SAES Getters, Italy: Shape Memory Award. Euros 35000 (declined, for the enrolment in the UNIPI PhD program; IP passed to SAES Getters for 5000 Euros).

2007 – 2008 Scholarship, School of Engineering: Bioengineering and Robotics Research Center "E. Piaggio", University of Pisa (UNIPI), Italy. Topic: Haptic Device Control

**MEMBERSHIPS OF SCIENTIFIC SOCIETIES**

2018- *present* Vice chair for Information Dissemination of IEEE Robotics and Automation Society (RAS) Technical Committee (TC) on Haptics (IEE, RAS Member since 2012)

2017 -*present* Co-chair of the IEEE RAS TC on Robot Hands, Grasping and Manipulation

2014 -present Member of the Eurohaptics Society

2013-*present* Member of SIDRA (Italian Society on Robotics and Automation)

**ORGANISATION OF SCIENTIFIC MEETINGS**

2018 Organizer of the Robotics Jam Sessions. School of Engineering. UNIPI. Pisa

2018 Robotics Science and Systems (RSS). Senior Member of the Program Committee: Area Chair for Mechanism/Design; Human-Robot Interaction; Human Cent. Systems; Manipulation. Pittsburgh

2018 Eurohaptics. Organizing Committee: Student Volunteer and Poster Award Chair, Pisa

2018 IEEE ICUMT, Program Committee: Control Systems TPC Chair. Moscow

2018 IEEE/RSJ IROS, Organizer of the Workshop (WS) on "User-Centered Methods in HRI", Madrid

2018 IEEE RAS RoboSoft, Organizer of the Workshop (WS) on "SoftHaptics", Livorno

2018 ICNR, Organizer Special Session on: New perspectives in upper limb prosthetic", Pisa

2017 International Workshop on Human-Friendly Robotics, Program Committee, Naples

2017 IEEE ICUMT, Program Committee: Control Systems TPC Chair. Munich

2016 IEEE ICUMT, Program Committee: Control Systems TPC Chair. Lisbon

2016 IEEE ICRA, Organizer of the Workshop on "Grasping and Manipulation Datasets", Stockholm

2016 IEEE Haptics Symp. WS Organizer: "Human and Robot Hands/Human and Robot Touch", Philadelphia.

2014 Eurohaptics, Organizer of the WS on "Haptics in Rehab., Prosthetics, Neural Engineering" and WS on: "Multisensory Softness", Versailles (France)

2014 IEEE Haptics Symp., Organizer of the WS on "Artificial Softness", Houston

**INSTITUTIONAL RESPONSIBILITIES**

2016 – *present* Faculty member, School of Eng. & Department of Information Eng., UNIPI, Italy

2018 – *present* Member of the PhD School in Information Eng. UNIPI, Italy

2018 – *present* Member of the Executive Committee, Cross-Lab in Augmented Reality, Department of Information Engineering, UNIPI, Italy

**REVIEWING ACTIVITIES**

2019, 2018 ICRA, Associate Editor

2016 –*present* Associate Editor, IEE Robotics and Automation Letters (RAL)

2016 – *present* Editorial Board, Int. Journal of Advanced Robotic Systems

2018 – *present* RAL Guest Editor. Special issue on "Soft Haptics"

2016 – *present* Review Editor in Bionics and Biomimetics, Frontiers in Robotics and AI

2018 IEEE Conf. Control Tech. and Applications; Eurohaptics; IROS: Associate Editor

2017 – 2018 Guest Editor, Frontiers in Robotics and AI: "Mapping Human Sensory-Motor Skills for Manipulation onto the Design and Control of Robots"

2017, 2018 PhD Panelist/Reviewer: PhD program Bioengineering & Robotics, IIT

2017 Worldhaptics Conference: Associate Editor

2016 Editor of the Book "Human and Robot Hands", Springer Series on Touch and Haptic Systems

2016 Expert Evaluator. Agence Nationale de la Recherche, France

2016, 2017 Expert Evaluator. Estonian Research Council (ETAg), Estonia

2015, 2017 ICORR Conference: Associate Editor

2014, 2016, 2018 BioRob Conference: Associate Editor

## Room and Schedule

Room: *Aula Riunioni Piano 6 del Dipartimento di Ingegneria dell'Informazione, Largo Lucio Lazzarino 1, Pisa*

Schedule:

- 13 Dicembre 10.30-13.00 & 14.30 - 17.00
- 14 Dicembre 10.30-13.00 & 14.30 - 17.00
- 17 Dicembre 10.30-13.00 & 14.30 - 17.00
- 18 Dicembre 10.30-13.00 & 14.30 - 17.00