Carmelo (Carlo) Sferrazza

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Education

2017-2021 **Ph.D. Candidate, ETH Zurich, Switzerland**
Institute for Dynamic Systems and Control. Advisor: Prof. Raffaello D'Andrea.
Committee: Prof. K. Goldberg, Prof. R. Kramer-Bottiglio, Dr. K. J. Kuchenbecker.
Dissertation title: "A general framework for high-resolution robotic tactile sensing: design, simulation, and learning." Defense date: December 13, 2021.

2014-2016 **M.Sc., ETH Zurich, Switzerland**
Robotics, Systems and Control. Awarded with distinction.
Thesis title: "Parametrized Model Predictive Control on the Flying Platform: Trajectory Tracking and Full Constraint Satisfaction."

2012-2013 **B.Eng., Tongji University, China**
Electronics and Information Engineering. Double degree program.
Thesis title: "Single Shooting as a Trajectory Optimization Method for Quadcopters."

2011-2014 **B.Sc., Politecnico di Milano, Italy**
Automation Engineering. Final grade: 110/110 with honors.

Academic appointments

2022- **Postdoctoral Researcher, ETH Zurich, Switzerland**
Institute for Dynamic Systems and Control, with Prof. Raffaello D'Andrea. Starting April 2022.

2017-2022 **Research Assistant, ETH Zurich, Switzerland**
Institute for Dynamic Systems and Control, with Prof. Raffaello D'Andrea.

Awards and Honors

2021 **Participant in the workshop "The Future of Tactile Sensing."**
The invitation-only workshop was organized by Meta (Facebook) AI Research and several distinguished professors, and was limited to 50 of the top researchers in the field.

2021 **Best Poster Award.**
At the IEEE ICRA Workshop on "Bridging the Gap between Data-driven and Analytical Physics-based Grasping and Manipulation."
For the workshop paper "Tactile swing-up: A testbed for tactile-enabled learning, estimation and control [W2]."

2021 **ETH representative to the Global Young Scientists Summit (GYSS)**
The GYSS is a multi-disciplinary gathering of young scientists and researchers from all over the world, with eminent speakers who are recipients of the Nobel Prize, Fields Medal, Millennium Technology Prize, and Turing Award.

2020 **Best Paper Award**
At the IEEE International Conference on Soft Robotics (RoboSoft).
For the paper "Towards vision-based robotic skins: a data-driven, multi-camera tactile sensor [C4]."

2017 **ETEL Master Award**
For the best Master's thesis in mechatronics at ETH Zurich.

2013 **Prize for "The Best Freshmen Students"**
Conferred on the basis of academic achievements in the first year of all Bachelor degrees at Politecnico di Milano.

2012 **Politong Scholarship**
To take part in a double degree program between Politecnico di Milano and Tongji University.

Publications

Journal Articles

[J1] C. Sferrazza and R. D'Andrea, "Sim-to-real for high-resolution optical tactile sensing: From images to 3D contact force distributions," *Soft Robotics*, 2021.

[J2] T. Bi, C. Sferrazza and R. D'Andrea, "Zero-shot sim-to-real transfer of tactile control policies for aggressive swing-up manipulation," *IEEE Robotics and Automation Letter (RA-L)*, 2021.

[J3] M. Hofer, C. Sferrazza and R. D'Andrea, "A Vision-based Sensing Approach for a Spherical Soft Robotic Arm," *Frontiers in Robotics and AI*, vol. 8, 2021.

[J4] C. Sferrazza, M. Muehlebach and R. D'Andrea, "Learning-based parametrized model predictive control for trajectory tracking," *Optimal Control Applications and Methods*, vol. 41, no. 6, pp. 2225–2249, 2020.

[J5] C. Sferrazza, A. Wahlsten, C. Trueeb and R. D'Andrea, "Ground Truth Force Distribution for Learning-Based Tactile Sensing: A Finite Element Approach," *IEEE Access*, vol. 7, pp. 173 438–173 449, 2019.

[J6] C. Sferrazza and R. D'Andrea, "Design, Motivation and Evaluation of a Full-Resolution Optical Tactile Sensor," *Sensors*, vol. 19(4), p. 928, 2019.

Conference Proceedings (full paper, peer-reviewed)

[C1] P. Griffa, C. Sferrazza and R. D'Andrea, "Leveraging distributed contact force measurements for slip detection: a physics-based approach enabled by a data-driven tactile sensor," *IEEE International Conference on Robotics and Automation (ICRA)*, 2022 (accepted).

[C2] C. Sferrazza, T. Bi and R. D'Andrea, "Learning the sense of touch in simulation: a sim-to-real strategy for vision-based tactile sensing," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 4389–4396, 2020.

[C3] P. Werner, M. Hofer, C. Sferrazza and R. D'Andrea, "Vision-Based Proprioceptive Sensing: Tip Position Estimation for a Soft Inflatable Bellow Actuator," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 8889–8896, 2020.

[C4] C. Trueeb, C. Sferrazza and R. D'Andrea, "Towards vision-based robotic skins: a data-driven, multi-camera tactile sensor," *Proceedings of the IEEE International Conference on Soft Robotics (RoboSoft)*, pp. 333–338, 2020. **Best Paper Award Winner**.

[C5] C. Sferrazza and R. D'Andrea, "Transfer learning for vision-based tactile sensing," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 7961–7967, 2019.

[C6] C. Sferrazza, M. Muehlebach and R. D'Andrea, "Trajectory Tracking and Iterative Learning on an Unmanned Aerial Vehicle using Parametrized Model Predictive Control," *Proceedings of the IEEE Conference on Decision and Control (CDC)*, pp. 5186–5192, 2017.

[C7] M. Muehlebach, C. Sferrazza and R. D'Andrea, "Implementation of a Parametrized Infinite-Horizon Model Predictive Control Scheme with Stability Guarantees," *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, pp. 2723–2730, 2017.

[C8] C. Sferrazza, D. Pardo and J. Buchli, "Numerical Search for Local (Partial) Differential Flatness," *Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 3640–3646, 2016.

Abstracts, Posters and Workshops

[W1] C. Sferrazza and R. D'Andrea, "A general framework for high-resolution tactile sensing: How physical abstractions simplify robotics applications," *The Future of Tactile Sensing Workshop*, 2021, presentation.

[W2] C. Sferrazza, T. Bi, P. Werner and R. D'Andrea, "Tactile swing-up: A testbed for tactile-enabled learning, estimation and control," *Bridging the Gap between Data-driven and Analytical Physics-based Grasping and Manipulation II at IEEE ICRA*, 2021, two-page paper, presentation and poster. **Best Poster Award Winner**.

[W3] C. Sferrazza and R. D'Andrea, "Accurate estimation of the 3D contact force distribution – Live demonstration," *ViTac Workshop at IEEE ICRA*, 2020, two-page paper and presentation.

[W4] M. Hofer, P. Werner, C. Sferrazza and R. D'Andrea, "Tip Position Estimation of a Soft Inflatable Bellow Actuator: A Vision-Based Proprioceptive Sensing Approach," *Beyond Soft Robotics Workshop at IEEE ICRA*, 2020, one-page paper.

[W5] C. Sferrazza, M. Muehlebach and R. D'Andrea, "Iterative learning for the generation and tracking of trajectories using parametrized model predictive control," *Max Planck ETH Workshop on Learning Control at ETH Zurich*, 2018, abstract and presentation.

[W6] C. Sferrazza, D. Pardo and J. Buchli, "Numerical Search for (Partial) Differential Flatness," *Workshop on Dynamic Locomotion and Manipulation at ETH Zurich*, 2016, abstract and poster.

Online Articles and Blog Posts

[O1] C. Sferrazza, "Robots that feel by seeing," *Robohub*, 2021, https://robohub.org/robots-that-feel-by-seeing/.

[O2] C. Sferrazza, "The significance of (online) public talks," *ETH Ambassadors*, 2020, https://ethambassadors.ethz.ch/2020/12/24/the-significance-of-online-public-talks/.

Invited Talks and Demonstrations

Research Seminars

2022 **Meta (Facebook) AI Research, USA**
Academic talk. "A general framework for high-resolution robotic tactile sensing: design, simulation, learning, and applications to robot control."

2021 **Max Planck Institute for Intelligent Systems, Germany**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to robot control." Hosted by Prof. Katherine Kuchenbecker.

2021 **Autonomy Talks, ETH Zurich, Switzerland**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to

robot control."

2021 **Institute for Automatic Control, ETH Zurich, Switzerland**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to robot control."

2021 **University of Toronto, Canada**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to robot control." Hosted by Prof. Angela Schoellig and the Robotics Institute.

2021 **UC Berkeley, USA**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to robot control." Hosted by Prof. Ken Goldberg.

2021 **UCLA, USA**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to robot control." Hosted by Prof. Robert M'Closkey and the Department of Mechanical and Aerospace Engineering.

2021 **RWTH Aachen University, Germany**
Academic talk. "Data-driven, vision-based tactile sensing: design, simulation, and applications to robot control." Hosted by Prof. Sebastian Trimpe.

2020 **Autonomy Talks, ETH Zurich, Switzerland**
Academic talk. "Optical touch: From tactile images to contact force distributions."

General Public Events

2020 **TEDxZurich, Zurich, Switzerland**
Presenter. "Robots that feel by seeing." Talk viewed online by 43,000 people (Apr 2022). https://youtu.be/IXKovDtgD_8

2020 **Swiss Science Center Technorama, Winterthur, Switzerland**
Demonstration. "Robotic skin." Technorama is the premier science center in Switzerland and one of the largest in Europe.

2019 **WORLD.MINDS Annual Symposium, Zurich, Switzerland**
Presenter. "Optical Touch." WORLD.MINDS is a community of 1,000 individuals who have made proven contributions in science, the arts, business and government. https://youtu.be/ece2Fl6a5fY

2019 **House of Electronic Arts, Basel, Switzerland**
Presenter. "AI in robotics for tactile skins."

2019 **World Economic Forum, Davos, Switzerland**
Demonstration. "The Cubli cube can move by itself."

Teaching Experience

2018- **Recursive Estimation, ETH Zurich, Switzerland**
Teaching assistant. Graduate course, approx. 300 students. Teaching weekly recitation classes, serving as substitute lecturer, developing problem sets, programming exercises and exams, grading, offering student office hours, maintaining the class website, recruiting and supervising junior TAs. Lecturer: Prof. Raffaello D'Andrea.

2015-2016 **Linear System Theory, ETH Zurich, Switzerland**
Reader. Graduate course. Grading homework and midterm exams. Lecturers: Prof. John Lygeros, Prof. Maryam Kamgarpour.

Student Supervision

Directly supervising B.Sc. and M.Sc. students at ETH, with the professor occasionally consulted. Responsibilities included student recruitment, the definition of appropriate student projects, research progress meetings, introduction to hardware testbeds, evaluation, and support in writing papers and preparing presentations.

M.Sc. Thesis (six-month, full-time research project)

[M1] Pietro Griffa, "Tactile-Enabled Robotic Grasping," *ETH Zurich*, 2021.

[M2] Thomas Bi, "Learning Aggressive Tactile Swing-Up Maneuvers," *ETH Zurich*, 2020. **Awarded ETH Medal and Willi Studer Prize for the Best Master's Degree**.

[M3] Camill Trueeb, "An End-to-End Approach to Multi-Camera Tactile Sensing," *ETH Zurich*, 2019. **ETEL Master Award Winner**.

[M4] Yipai Du, "Learning Dynamical Features for Vision-based Tactile Sensors," *ETH Zurich (exchange student from KTH Stockholm)*, 2019.

[M5] Benita Nortmann, "A State-Dependent Approach to Learning-Based Model Predictive Control," *ETH Zurich (exchange student from Imperial College London)*, 2019.

Master Semester Project (semester-long research project)

[S1] Peter Werner, "Trajectory Generation for Tactile-Enabled Robotic Manipulation," *ETH Zurich*, 2021.

[S2] Felix Schmitt-Koopmann, "Few-Shot Learning for a Tactile Sensor," *ETH Zurich*, 2021.

[S3] Thomas Bi, "Generation of Optical Flow from Finite Element Simulations: Applications to Tactile Sensing," *ETH Zurich*, 2020.

[S4] Camill Trueeb, "Automated FEA Simulations to Provide Ground Truth for Tactile Sensing," *ETH Zurich*, 2018.

[S5] Laura Maria Gasser, "Feature Engineering for an Optical Tactile Sensor," *ETH Zurich*, 2018.

[S6] Zhejun Zhang, "Improving the Trajectory Tracking of a Parametrized MPC Approach," *ETH Zurich (jointly supervised with Michael Muehlebach)*, 2017.

B.Sc. Thesis (three-month, full-time research project)

[B1] Peter Werner, "Time of Flight and Camera Based Sensing for an Air-Driven Linear Soft Actuator," *ETH Zurich (jointly supervised with Matthias Hofer)*, 2019. **Awarded SGA (Swiss Society for Automatic Control) prize**.

Professional Activities

2020 **Scientific staff representative in the Faculty Selection Committee at ETH Zurich**
For an Assistant Professor position in the Department of Mechanical and Process Engineering and the Department of Civil, Environmental and Geomatic Engineering.

2019 **Session Chair at IEEE/RSJ IROS**
For the session "Force and Tactile Sensing".

2017- **Journal Paper Reviews**
IEEE Robotics and Automation Letters (RA-L)
Scientific Reports (Sci. Rep.)
Sensors
Journal of Guidance, Control, and Dynamics
Bioinspiration & Biomimetics
IEEE Transactions on Cognitive and Developmental Systems

2017- **Conference Paper Reviews**
IEEE International Conference on Robotics and Automation (ICRA)
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
IEEE Conference on Decision and Control (CDC)
Learning for Dynamics & Control Conference (L4DC)
IFAC World Congress

Research Videos

[V1] P. Griffa, C. Sferrazza, and R. D'Andrea, *Leveraging distributed contact force measurements for slip detection: a physics-based approach*, Sep. 2021. [Online]. Available: https://youtu.be/YeotGbKVWcY.

[V2] C. Sferrazza and R. D'Andrea, *Sim2real for high-resolution optical tactile sensing: From images to 3D contact force distributions*, Sep. 2021. [Online]. Available: https://youtu.be/dvOk2XrSmLE.

[V3] T. Bi, C. Sferrazza, and R. D'Andrea, *Zero-shot sim-to-real transfer of tactile control policies for aggressive swing-up manipulation*, Apr. 2021. [Online]. Available: https://youtu.be/In4jkaHzJLc.

[V4] C. Sferrazza, T. Bi, and R. D'Andrea, *Learning the sense of touch in simulation: a sim-to-real strategy for vision-based tactile sensing*, Mar. 2020. [Online]. Available: https://youtu.be/dDTga9PgWS0.

[V5] C. Trueeb, C. Sferrazza, and R. D'Andrea, *Towards vision-based robotic skins: a data-driven, multi-camera tactile sensor*, Oct. 2019. [Online]. Available: https://youtu.be/lbavqAlKl98.

[V6] C. Sferrazza, A. Wahlsten, C. Trueeb, and R. D'Andrea, *Ground truth force distribution for learning-based tactile sensing: a finite element approach*, Sep. 2019. [Online]. Available: https://youtu.be/9A-cONrsiOg.

[V7] C. Sferrazza and R. D'Andrea, *Transfer learning for vision-based tactile sensing*, Mar. 2019. [Online]. Available: https://youtu.be/CdYK5I6Sccw.

[V8] C. Sferrazza, M. Muehlebach, and R. D'Andrea, *Learning based parametrized model predictive control for trajectory tracking*, Oct. 2018. [Online]. Available: https://youtu.be/-E4znjVDCyA.

[V9] C. Sferrazza and R. D'Andrea, *Design, motivation and evaluation of a full-resolution optical tactile sensor*, Feb. 2019. [Online]. Available: https://www.mdpi.com/1424-8220/19/4/928/s1.

Selected Media Coverage

2020 "Machine learning helps researchers build low-cost tactile sensor," *The Robot Report.*

2020 "Allowing robots to feel," *ETH News.*

2020 "Sensor skin could give robot grippers a delicate touch," *New Atlas.*

2020 "A deep learning-based method for vision-based tactile sensing," *Tech Xplore.*

2019 "Robotic Skin Sees When (and How) You're Touching It," *Hackaday.*

2019 "Tactile sensor could enable soft robot skins," *Fierce Electronics.*

2019 "A multi-camera optical tactile sensor that could enable vision-based robotic skins," *Tech Xplore.*

2019 "The Best Machine Learning Research of 2019 So Far," *Open Data Science on Medium.com.*

Additional Experience and Education

2020 **ETH transfer and European Patent Academy, ETH Zurich, Switzerland**
"Workshop on Intellectual Property Rights." Two-day intensive course.

2016 **GE (ex-Alstom) Inspection Robotics, Switzerland**
Six-month internship as Navigation Software Developer. Developing and testing navigation and control software for inspection robots.

2014 **Athens Programme, Technical University Munich, Germany**
"Manipulation of time series in time and frequency spectrum." One-week intensive course.

Personal Information

Languages
Italian (mother tongue)
English (fluent)
German (intermediate)
Mandarin Chinese (basic)

Italian citizen