Tobia Marcucci

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Research interests

My research sits at the intersection of convex and combinatorial optimization, with applications to robotics, motion planning, and control. I study optimal decision making in circumstances where discrete and continuous choices have to be made simultaneously. I work on these problems on a mathematical and numerical level: I design efficient problem formulations and fast solution algorithms.

Research experience

- **Amazon Robotics** 6/2024 to 5/2025
  Postdoctoral scientist

Education

- **Massachusetts Institute of Technology** 6/2018 to 5/2024
  PhD student with Russ Tedrake and Pablo Parrilo
  Thesis: Graphs of Convex Sets with Applications to Optimal Control and Motion Planning
  Major: Computer science (System Science and Control Engineering)
  Minor: Mathematics (Abstract Algebra)
  GPA: 4.8/5
- **Stanford University** 11/2022 to 10/2023
  Visiting PhD student with Stephen Boyd
- **Massachusetts Institute of Technology** 1/2017 to 11/2017
  Visiting PhD student with Russ Tedrake
- **University of Pisa and Istituto Italiano di Tecnologia** 9/2015 to 1/2018
  PhD student with Antonio Bicchi (uncompleted, moved to MIT)
- **University of Pisa** 12/2013 to 9/2015
  Master's Degree in Mechanical Engineering
  Graduation grade: 110/110 cum laude
  GPA: 30.0/30
- **University of Pisa** 11/2010 to 11/2013
  Bachelor's Degree in Mechanical Engineering
  Graduation grade: 110/110
  GPA: 27.2/30

Journal publications

- **Shortest Paths in Graphs of Convex Sets** 2024
  Tobia Marcucci, Jack Umenberger, Pablo A. Parrilo, and Russ Tedrake
  SIAM Journal on Optimization
- **Fast Path Planning Through Large Collections of Safe Boxes** 2023
  Tobia Marcucci, Parth Nobel, Russ Tedrake, and Stephen Boyd
  Accepted for publication in IEEE Transactions on Robotics (TRO)
  Preprint arXiv:2305.01072

- **Motion Planning around Obstacles with Convex Optimization** 2023
  Tobia Marcucci, Mark Petersen, David von Wrangel, and Russ Tedrake
  Science Robotics
  - Cover of November 2023 issue
  - IEEE RAS TC Model Based Optimization for Robotics Best Paper Award
- **Warm Start of Mixed-Integer Programs for Model Predictive Control of Hybrid Systems** 2020
  Tobia Marcucci and Russ Tedrake
  IEEE Transactions on Automatic Control (TAC)
- **A Two-Stage Trajectory Optimization Strategy for Articulated Bodies with Unscheduled Contact Sequences** 2017
  Tobia Marcucci, Marco Gabiccini, and Alessio Artoni
  IEEE Robotics and Automation Letters (RAL)

Conference publications

- **Multi-Query Shortest-Path Problem in Graphs of Convex Sets** 2024
  Savva Morozov, Tobia Marcucci, Alexandre Amice, Bernhard Paus Graesdal, Rohan Bosworth, Pablo A. Parrilo, and Russ Tedrake
  Under review in International Workshop on the Algorithmic Foundations of Robotics (WAFR)
- **On the Sample Complexity of Imitation Learning for Smoothed Model Predictive Control** 2024
  Daniel Pfrommer, Swati Padmanabhan, Kwangjun Ahn, Jack Umenberger, Tobia Marcucci, Zakaria Mhammedi, and Ali Jadbabaie
  Under review in IEEE Conference on Decision and Control (CDC)
- **Towards Tight Convex Relaxations for Contact-Rich Manipulation** 2024
  Bernhard P. Graesdal, Shao Y.C. Chia, Tobia Marcucci, Savva Morozov, Alexandre Amice, Pablo A. Parrilo, and Russ Tedrake
  Robotics: Science and Systems (RSS)
- **Approximating Robot Configuration Spaces with few Convex Sets using Clique Covers of Visibility Graphs** 2024
  Peter Werner, Alexandre Amice, Tobia Marcucci, Daniela Rus, and Russ Tedrake
  IEEE International Conference on Robotics and Automation (ICRA)
- **Smooth Model Predictive Control with Applications to Statistical Learning** 2023
  Kwangjun Ahn, Daniel Pfrommer, Jack Umenberger, Tobia Marcucci, Zak Mhammedi, and Ali Jadbabaie
  Preprint arXiv:2306.01914
- **Model-Based Control with Sparse Neural Dynamics** 2023
  Ziang Liu, Jeff He, Genggeng Zhou, Tobia Marcucci, Li Fei-Fei, Jiajun Wu, and Yunzhu Li
  Conference on Neural Information Processing Systems (NeurIPS)
- **Mixed-Integer Formulations for Optimal Control of Piecewise-Affine Systems** 2019
  Tobia Marcucci and Russ Tedrake
  ACM International Conference on Hybrid Systems: Computation and Control (HSCC)
- **Approximate Hybrid Model Predictive Control for Multi-Contact Push Recovery in Complex Environments** 2017
  Tobia Marcucci, Robin Deits, Marco Gabiccini, Antonio Bicchi, and Russ Tedrake
  IEEE International Conference on Humanoid Robots (Humanoids)
- **Parametric Trajectory Libraries for Online Motion Planning with Application to Soft Robots** 2017
  Tobia Marcucci, Manolo Garabini, Gian Maria Gasparri, Alessio Artoni, Marco Gabiccini, Antonio Bicchi
  International Symposium on Robotic Research (ISRR)
- **Towards Minimum-Information Adaptive Controllers for Robot Manipulators** 2017
  Tobia Marcucci, Cosimo Della Santina, Marco Gabiccini, and Antonio Bicchi
  IEEE American Control Conference (ACC)

Workshops and extended abstracts

- **A Tight Semidefinite Relaxation for Linear and Hybrid Optimal Control with Time Scaling** 2024
  Lujie Yang, Tobia Marcucci, and Russ Tedrake

Robotics: Science and Systems (RSS), workshop on Frontiers of Optimization for Robotics (FOR)

- **Approximate Explicit Model Predictive Control for Push Recovery Using Mixed-Integer Convex Optimization** 2017
  Robin Deits, Tobia Marcucci, Lucas Manuelli, Twan Koolen, and Russ Tedrake
  Dynamic Walking

Teaching experience

Teaching assistant:

- *Underactuated Robotics* Spring 2020
  Graduate course taught by Russ Tedrake at MIT
  - Gave two lectures (available on the class YouTube channel)
  - Developed the exercises in the class lecture notes
- *Automatic Controls and Robot Mechanics* Fall 2015
  Graduate course taught by Antonio Bicchi and Marco Gabiccini at the University of Pisa
  - Gave multiple lectures

Guest lecturer:

- *Optimal Control: from Calculus of Variations to Numerical Optimization* Summer 2020
  PhD course taught by Manolo Garabini at the University of Pisa
  - Lecture material available at https://github.com/TobiaMarcucci/optimal_control_pisa
- *Intelligent Robot Manipulation* Fall 2018
  Graduate course taught by Russ Tedrake and Tomás Lozano-Pérez at MIT

Workshop organization

- **Decision and Control Blending Combinatorial and Continuous Optimization** 2023
  SIAM Conference on Optimization
- **Optimal planning and control fusing offline and online algorithms** 2019
  IEEE International Conference on Robotics and Automation

Invited talks

Motion Planning around Obstacles with Convex Optimization:

- Stanford University (Interactive Perception and Robot Learning Laboratory) 7/2023
- University of California Berkeley (EECS Seminar) 5/2023
- Stanford University (SystemX Robotics Spotlights) 2/2023
- Cornell University (Verifiable Robotics Group) 10/2022
- Istituto Italiano di Tecnologia (iCub Research Lines) [recording] 9/2022
- Presented by Russ Tedrake: Robotics Seminar (MIT) [recording], ME Seminar (Columbia University), Seminar at The Robotics Institute (CMU) [recording], Seminars on Computational Geometry and Robotics (Tel Aviv University) [recording], Keynote at WAFR 2022 [recording], Seminar at Contextual Robotics Institute (UCSD), Seminar at GRASP on Robotics (University of Pennsylvania) [recording]

Shortest Paths in Graphs of Convex Sets:

- INFORMS Annual Meeting (Session on "Global optimization") 10/2023
- SIAM Conference on Optimization (Session on "Decision and control blending combinatorial and continuous optimization") 6/2023
- Stanford University (Linear Algebra and Optimization Seminars) 1/2023
- Joint Mathematics Meetings (SIAM mini-symposium in combinatorial optimization) 1/2023
- International Conference on Optimization and Decision Science (Session on "Path and routing problems in industry") 8/2022
- Université Catholique de Louvain (Cyber-Physical Systems Laboratory) 5/2022
- IMT School for Advanced Studies Lucca 12/2021

- Stanford University (Autonomous Systems Laboratory) 11/2021
- University of California Berkeley (MPC Laboratory) 11/2021
- California Institute of Technology (AMBER Laboratory) 11/2021
- Massachusetts Institute of Technology (Embodied Intelligence Submissions Seminars) 9/2021
- Presented by Pablo Parrilo: Semi-Plenary at ICCOPT 2022

Others:

- *Control through Contacts via Approximate Explicit Model Predictive Control* 5/2019
  IEEE International Conference on Robotics and Automation
  Workshop on optimal planning and control fusing offline and online algorithms

Invited posters

Shortest Paths in Graphs of Convex Sets:

- Brown University (ICERM workshop on Linear and Non-Linear Mixed Integer Optimization) 2/2023
- Cornell University (ORIE Young Researchers Workshop) 10/2022

Awards

- IEEE RAS TC Model Based Optimization for Robotics Best Paper Award 2023
- SIAM Student Travel Award 2023
- Grass Instruments Company Fellow 9/2018 to 5/2019

Service

- **Co-chair** 2017
  Session "Robotics I"
  IEEE American Control Conference
- **Reviewer**
  International journals and conferences, including: IEEE Transactions on Automatic Control (TAC), Journal of Robust and Nonlinear Control, IEEE Control Systems Letters (CSS), International Journal of Robotics Research (IJRR), IEEE Transactions on Robotics (TRO), IEEE Robotics and Automation Letters (RAL), and Journal of Optimization Theory and Applications (JOTA)

Miscellaneous academic achievements

- Grade of A+ in more than half of the classes taken in the PhD at MIT
- Grade of A+ in all the classes taken for the minor in mathematics in the PhD at MIT
- Highest GPA among the students enrolled in 2013 in the master program in Mechanical Engineering at the University of Pisa
- Only student enrolled in 2010 in Mechanical Engineering at the University of Pisa to complete bachelor and master within 5 years (approximately 90% of the students take more than 6 years)