Curriculum Vitæ

Riccardo Bonalli

Born the 19th November 1989 in Varese (Italy)

Ph.D. Applied Mathematics

Postdoctoral Researcher
Autonomous Systems Laboratory (ASL)
Stanford Aeronautics & Astronautics

William F. Durand Building,
496 Lomita Mall, Stanford, CA 94305-4035

rbonalli@stanford.edu
https://rbonalli.github.io

---

1 Academic Positions

- From 07/2018: Postdoctoral Researcher at the Autonomous Systems Laboratory (Director Prof. Marco Pavone), Aeronautics & Astronautics Department at Stanford University (USA), under a NASA Early Career Faculty Grant.

---

2 Education

- 04/2015-07/2018: Ph.D. in Applied Mathematics, Sorbonne Université, Paris (France). Collaboration between ONERA - The French Aerospace Lab and Laboratoire Jacques-Louis Lions. Advisors: Prof. Emmanuel Trélat (Sorbonne Université) and Dr. Bruno Hérissé (ONERA).
- 09/2012-12/2014: MSc in Mathematical Engineering, Politecnico di Milano, Milan (Italy). Graduated with 111.75/110. Total SCH: 245/200.
- 09/2008-09/2011: BSc in Physical Engineering, Politecnico di Milano, Milan (Italy).
- 2008: Scientific High-School Diploma, Liceo Scientifico "Sereni", Luino (Italy).

---

3 Awards and Distinctions

- 2018 : Best Ph.D. thesis at ONERA - TIS Department.
  https://www.onera.fr/fr/rejoindre-onera/prix-des-doctorants (French)

---

4 Research Interests

My research activities concern infinite dimensional optimization, control and mechanical systems theory, theoretical and numerical reinforcement learning and their applications to robust and optimal control. I am particularly interested in leveraging information from a theoretical analysis of the problem to design efficient numerical algorithms. So far, I have combined techniques from differential geometry, dynamical systems theory and both deterministic and stochastic optimal control to allow algorithms to compute optimal strategies involving highly complex systems in real-time. During my Ph.D., I have focused on optimal control problems coming from aerospace, such as endo/exo-atmospheric rendezvous, and motion planning in aeronautics. I have also provided state-of-the-art C++ based softwares for fast predictions of missile interception missions. Since I have started my postdoc in the Department of Aeronautics & Astronautics at Stanford University, I have been focusing on several topics: theoretical and numerical developments for sequential convex programming, path-planning and human-robot interaction, Generalized Riemannian Motion Policy (GRMP) and reinforcement learning procedures. The main objective consists of computing optimal controls in real time for a wide range of robotic systems (including freeflyers, robotic manipulators and quadrotors), usually under uncertainty and in the presence of non-Euclidean geometries. Some of those algorithms have successfully been tested by NASA on real challenging scenarios aboard the International Space Station (ISS) (September 2019). I have recently started to adapt such paradigms to solve non-linear optimal control problems involving high-dimensional systems (in the context of optimal control for partial differential equations).

- **Infinite Dimensional Optimization:** continuity properties of variational principles (e.g., Lagrange multiplier rules for nonlinear constrained optimization problems) in optimal control and the calculus of variations, non-linear optimization in Banach spaces.
- **Finite Dimensional Control Theory:** Riemannian and symplectic geometry applied to geometric control, dynamical systems theory, maximum principles, high order necessary and sufficient optimality conditions, optimal control problems with control and state constraints, optimal control problems with delays in the state and in the control.
- **Analysis of Numerical Methods for Optimal Control:** sequential convex and quadratic programming, MPC, direct and indirect shooting and multi-shooting methods for optimal control problems with state constraints and delays, numerical homotopy and continuation methods, motion planning and GRMP with application to high frequency re-planning, theoretical and numerical analysis of reinforcement learning algorithms applied to optimal control.
- **Applications:** real-time optimal control of launch vehicle systems involved in rendezvous problems, atmospheric reentry and satellite orbit transfert, real-time optimal control of freeflyers and robotic manipulators for sensitive operations on the ISS (human-robot interaction).

---

5 Publications

5.1 Preprint and Work in Progress Papers

1. M. Szmuk, D. Malyuta, T. P. Reynolds, **R. Bonalli**, B. Açıkmeşe and M. Pavone, *Convex Optimization-Based Trajectory Generation*. Work in progress to submit to IEEE Control Systems Magazine.

2. **R. Bonalli***, A. Bylard* and M. Pavone, *Generalization of Riemannian Motion Policies for Scalable and Modular Geometric Control*. Work in progress.

3. **R. Bonalli**, T. Lew and M. Pavone, *Solving Non-Linear Stochastic Optimal Control Problems via Sequential Convex Programming*. Work in progress.

5.2 Journal Papers

1. **R. Bonalli**, B. Hérissé and E. Trélat. *Optimal Control of Endo-Atmospheric Launch Vehicle Systems: Geometric and Computational Issues*. IEEE Transaction on Automatic Control, 65 (2020), pp. 2418–2433.

2. **R. Bonalli**, B. Hérissé and E. Trélat. *Continuity of Pontryagin Extremals with Respect to Delays in Nonlinear Optimal Control*. SIAM J. Control Optim., 57 (2019), pp. 1440–1466.

5.3 Conference Papers

1. T. Lew, **R. Bonalli**, and M. Pavone, *Chance-Constrained Sequential Convex Programming for Robust Trajectory Optimization*. European Control Conference, 2020, Saint Petersburg (Russia).

2. S. Banerjee, T. Lew, **R. Bonalli**, A. Alfaadhel, I. A. Alomar, H. M. Shageer, and M. Pavone, *Learning-based Warm-Starting for Fast Sequential Convex Programming and Trajectory Optimization*. IEEE Aerospace Conference, 2020, Big Sky (Montana).

3. M. Kleinbort, K. Solovey, **R. Bonalli**, E. Granados, K. E. Bekris, and D. Halperin, *RRT2.0 for Optimal Kinodynamic Sampling-Based Motion Planning*. International Conference on Robotics and Automation, 2020, Paris (France).

4. **R. Bonalli**, A. Cauligi, A. Bylard, T. Lew and M. Pavone, *Trajectory Optimization on Manifolds: A Theoretically-Guaranteed Embedded Sequential Convex Programming Approach*. Robotics: Science and Systems, 2019, Freiburg (Germany).

5. **R. Bonalli**, A. Cauligi, A. Bylard and M. Pavone, *GuSTO: Guaranteed Sequential Trajectory Optimization via Sequential Convex Programming*. International Conference on Robotics and Automation, 2019, Montreal (Canada).

6. **R. Bonalli**, B. Hérissé, H. Maurer and Emmanuel Trélat. *The Dubins Car Problem with Delay and Applications to Aeronautics Motion Planning Problems*. 18th French - German - Italian Conference on Optimization, 2017, Paderborn (Germany).

7. **R. Bonalli**, B. Hérissé and E. Trélat. *Analytical Initialization of a Continuation-Based Indirect Method for Optimal Control of Endo-Atmospheric Launch Vehicle Systems*. IFAC World Congress, 2017, Toulouse (France).

8. **R. Bonalli**, B. Hérissé and E. Trélat. *Solving Optimal Control Problems for Delayed Control-Affine Systems with Quadratic Cost by Numerical Continuation*. American Control Conference, 2017, Seattle (USA).

5.4 Ph.D. Thesis

- **R. Bonalli**, *Optimal Control of Aerospace Systems with Control-State Constraints and Delays*. Defended on July 13, 2018 (Sorbonne Université). Dissertation committee: Jean-Baptiste Caillau, Jean-Michel Coron, Bruno Hérissé, Nicolas Petit, Jean-Baptiste Pomet, Emmanuel Trélat and Hasnaa Zidani.

---

6 Workshops

- *Space Robotics*. Robotics: Science and Systems, 2019, Freiburg (Germany). Organizers: **R. Bonalli**, M. Pavone, N. Ahmed, D. Szafir, C. Heckman, J. McMahon and E. Komendera.

---

7 Invited Lectures and Talks

- May 24, 2019, *Real-time Optimal Control of Robotics Systems*. Talk at Concordia University, Montreal (Canada).
- May 15, 2019, *Real-time Optimal Control of Endo-Atmospheric Launch Vehicles*. Informal Systems Seminar at McGill University, Montreal (Canada).
- October 1, 2018, *Methods for Real-time Optimal Guidance of Launch Vehicles*. Ph.D. Students Welcome Day at ONERA - The French Aerospace Lab, Palaiseau (France).

---

8 Software and Hardware Experiments

- `GuSTO` - Julia package implementing GuSTO, a sequential convex programming paradigm for real-time trajectory optimization. Developed in collaboration with Andrew Bylard and Abhishek Cauligi during my Postdoc at Stanford University, this library combines ease-of-use with fast computations, providing solutions in real-time for many robotic systems. The open source code is available at: https://github.com/StanfordASL/GuSTO.jl.
- `SOCP` - C++ package implementing shooting for optimal control problems, specialized in launch vehicles. This paradigm has been developed during my Ph.D thesis in collaboration with Bruno Hérissé and it can compute optimal solutions for aerospace rendezvous problems in few milliseconds. A (partial) open source version is available at: https://github.com/bherisse/socp.
- Freeflyer experiments on simulated two-dimensional micro-gravity environment at Stanford University, in collaboration with Andrew Bylard and Abhishek Cauligi. The video is available at: https://www.youtube.com/watch?v=GHehE-If5nY.
- `Astrobee` - Real-time optimal control of the NASA robot Astrobee via GuSTO (in collaboration with Andrew Bylard and Abhishek Cauligi). Experiments considering sensitive operations on the International Space Station have been conducted in Summer 2019.

---

9 Teaching Activity

9.1 Graduate Courses

- Spring 2019 and Spring 2020: Teaching assistant for the course *Optimal and Learning-Based Control (AA203)* held at Stanford University by Prof. Marco Pavone.

9.2 Senior Undergraduate Courses

- 2015-2017: Teaching assistant for the course *Analysis and Stability of Dynamical Systems (AO102)* held at ENSTA ParisTech by Prof. Frédéric Jean.
- 2016-2017: Teaching assistant for the course *Quadratic Optimization (AO101)* held at ENSTA ParisTech by Prof. Hasnaa Zidani.

---

10 Student Supervision

10.1 Ph.D. Students

- Thomas Lew, Stanford University, from 09/2019 (at 50%).

  Ph.D. student in control for aerospace and robotics systems at Stanford University.
- Andrew Bylard, Stanford University, from 08/2018 (at 50%).

  Ph.D. student in control for aerospace and robotics systems at Stanford University.

10.2 Master Students

- Jonathan Lee, Stanford University, from 08/2019 (at 30%).
- Somrita Banerjee, Stanford University, 03/2018-08/2019 (at 30%).
- Quentin Chan-Wai-Nam, MINES ParisTech, 03/2017-08/2017 (at 30%).

---

11 Industrial Experiences

1. 03/2015 - 07/2018: Ph.D. thesis at ONERA - The French Aerospace Lab, Paris (France).

   Design of onboard methods for real-time computing of optimal strategies for launch vehicle systems. ONERA owns a software based on the latest version of my algorithm.
2. 2014: MSc Internship at IFP Energies Nouvelles, Paris (France).

   Six months of internship from March 2014 to August 2014 consisting of the improvement of algorithms inside a C++ thermodynamics library using different nonlinear optimization techniques.

---

12 Computer Skills

- Operating Systems: UNIX (Scientific Linux, Ubuntu), Mac OS, Windows.
- Programming Languages : GNU Bash, CMake, C, C++, Fortran90, Python, Julia, LaTeX.
- Softwares: MatLab, FreeFem++, Microsoft Office.

---

13 Others

- Languages: italian (mothertongue), english (fluent), french (fluent).
- Sports: rowing and judo (for which I participated in regional competitions), swimming, climbing and down-hill.
- Music: piano and classical guitar.
- Interests: viticulture, history, philosophical politics and politics.