Dr. Dario Bellicoso

Project and Controls Lead

Zurich, Switzerland

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Summary

Project and Controls Lead at the RAI Institute. Previously Senior Staff Research Scientist and Technical Lead for Reinforcement Learning at Boston Dynamics. Previously Senior Robotics Researcher and PhD Doctoral Researcher in robotic legged locomotion and manipulation for the Robotic Systems Lab, ETH Zurich, Switzerland, advised by Prof. Marco Hutter, Prof. Roland Siegwart, and Prof. Bruno Siciliano.

Professional Work

RAI Institute — *Zurich, Switzerland*

Project and Controls Lead — *April 2024 - Present*

- Leading the RAI Institute's robotics research activities.
- Developing learned policies for humanoid and quadrupedal robots.
- Delivered company-wide technical and progress updates.

Boston Dynamics — *Waltham, MA, USA*

Senior Staff Research Scientist and Technical Lead - Atlas, Spot — *June 2022 - March 2024*

- Led the Reinforcement Learning team to develop learned policies for the Atlas and Spot robots.
- Developed training and inference framework to deploy locomotion and manipulation policies on hardware.
- Delivered company-wide technical and progress updates.

Boston Dynamics — *Waltham, MA, USA*

Senior Staff Robotics Controls Engineer - Stretch — *January 2022 - May 2022*

- Led regular meetings for the Stretch motion planning team.
- Held technical presentations focused on controls, software programming, and research.
- Delivered technical reports and documentation for the Stretch motion planning and controls framework.

Boston Dynamics — *Waltham, MA, USA*

Robotics Controls Engineer - Stretch — *May 2019 - December 2021*

- Led design reviews and outlined the implementation plan for motion planning and control algorithms for Stretch, a mobile manipulator for logistics applications.
- Brought up controls and planning for the initial Stretch prototype.
- Developed controls and motion planning framework for multiple iterations of Stretch robots, from first prototype to product versions, allowing Stretch to successfully manipulate more than 1M customer boxes.
- Played a key role in mentoring colleagues, providing guidance in C++ programming, mathematics, numerical optimization, and core robotics concepts.

Education

ETH Zurich — *Zürich, Switzerland*

Postdoctoral Researcher in Robotics and Control — *January 2019 - April 2019*

- Coordinated locomotion and manipulation for walking robots equipped with robotic manipulators.

ETH Zurich — *Zürich, Switzerland*

PhD in Mechanical Engineering - Robotics and Control — *January 2015 - December 2018*

- Model-based whole-body control algorithms coupled with hierarchical optimization.
- Fast optimization-based motion planning for quadrupedal robots to execute a large variety of highly dynamic and robust gaits.

Università degli Studi di Napoli Federico II — *Naples, Italy*

Master Degree in Automation Engineering — *March 2014*

- Modeling, planning and control of a 3D printed robotic arm mounted on a UAV for aerial manipulation.
- Design of a communication protocol to operate a 3D printed robotic arm.

Università degli Studi di Napoli Federico II — *Naples, Italy*

Bachelor Degree in Automation Engineering — *March 2011*

- Control of an industrial robotic arm using a smartphone.
- Design and implementation of an app to access a smartphone's sensors to send reference signals to an industrial robotic arm.

Experience

Lab experience

Postdoctoral Researcher at the Robotic Systems Lab, ETH Zurich

- Supervisor and coordinator of research goals for PhD students on robotic legged locomotion and manipulation.

PhD Researcher at the Robotic Systems Lab, ETH Zurich

- Lab coordinator of research goals.
- Co-lecturer for the Robot Dynamics course at ETH Zurich.
- Supervisor and co-supervisor for several Master Thesis and Semester Projects at ETH Zurich.
- Lead researcher representing the Robotic Systems Lab for the National Centre of Competence in Research (NCCR).

Research assistant at the PRISMA Lab, Università degli studi di Napoli Federico II, Naples, Italy

- Research assistant for the ARCAS EU Project, coordinated by Prof. Bruno Siciliano.
- Lead software developer of a UAV equipped with a robotic arm.

Robotics Challenges

ARGOS Challenge

- Software and robotics engineer for team LIO at the ARGOS Challenge.
- Implementation a motion planner for a static walking gait for the quadrupedal robots StarlETH and ANYmal developed by the legged robotics group at the Autonomous Systems Lab.
- Contribution to the development of the locomotion software stack.
- *Pau, France. August 2014 - April 2016*

ERL Emergency Robotics

- Team leader for the ERL Emergency Robotics Challenge.
- Coordination of a team of robotics engineers and researchers to bring the quadrupedal robot ANYmal in a search & rescue scenario.
- *Piombino, Italy. September 2017*
- `https://youtu.be/qrJlMze_xhQ`

ARCHE

- Team leader for the ARCHE event for Search and Rescue robotics.
- Demonstration of the use of the quadrupedal robot ANYmal for a search and rescue mission in a real-world environment.
- *Wangen an der Aare, Switzerland. July 2018*
- `https://youtu.be/X6ScD93WH6U`

Skills

Programming	C++, Python
Software Infrastructure	GNU/Linux, ROS, Git, CMake, Bazel
Spoken Languages	Italian (mother tongue), English (second language), German (A2)

Open source software projects

ExPloy

- Exploy: EXport and dePLOY Reinforcement Learning policies.
- `https://github.com/bdaiinstitute/exploy`

Kindr

- Kinematics and Dynamics for Robotics. A C++ library which provides interfaces and implementations of kinematic and dynamic quantities for robotics.
- **`https://github.com/ANYbotics/kindr`**

DAMA ROB

- DArio and MArco's ROBotics toolbox, a robotics toolbox written for Matlab/Simulink which provides the equations of motion in symbolic form for a generic open chain mechanical system. The toolbox also generates a VR model for visualization.
- `http://www.damarob.altervista.org`

Publications

[1] C. D. Bellicoso, *Optimization-based planning and control for multi-limbed walking robots*, PhD thesis, ETH Zurich, 2019.

[2] C. D. Bellicoso, M. Bjelonic, L. Wellhausen, D. Sako, K. Holtmann, F. Guenther, M. Tranzatto, P. Fankhauser, and M. Hutter, *Advances in real-world applications for legged robots*, Journal of Field Robotics, 35 (2018), pp. 1311–1326.

[3] C. D. Bellicoso, L. R. Buonocore, V. Lippiello, and B. Siciliano, *Design, modeling and control of a 5-dof light-weight robot arm for aerial manipulation*, in Mediterranean Conference on Control and Automation (MED), 2015 23th, IEEE, 2015, pp. 853–858.

[4] C. D. Bellicoso, C. Gehring, J. Hwangbo, P. Fankhauser, and M. Hutter, *Perception-less terrain adaptation through whole body control and hierarchical optimization*, in International Conference on Humanoid Robots (Humanoids), 2016 IEEE-RAS 16th, IEEE, 2016, pp. 558–564.

[5] C. D. Bellicoso, F. Jenelten, P. Fankhauser, C. Gehring, J. Hwangbo, and M. Hutter, *Dynamic locomotion and whole-body control for quadrupedal robots*, in International Conference on Intelligent Robots and Systems (IROS), 2017 IEEE/RSJ, IEEE, 2017, pp. 3359–3365.

[6] C. D. Bellicoso, F. Jenelten, C. Gehring, and M. Hutter, *Dynamic locomotion through online nonlinear motion optimization for quadrupedal robots*, IEEE Robotics and Automation Letters, 3 (2018), pp. 2261–2268.

[7] C. D. Bellicoso, K. Krämer, M. Stäuble, D. Sako, F. Jenelten, M. Bjelonic, and M. Hutter, *Alma-articulated locomotion and manipulation for a torque-controllable robot*, in IEEE International Conference on Robotics and Automation (ICRA), 2019.

[8] T. Bi, P. Fankhauser, C. D. Bellicoso, and M. Hutter, *Real-time dance generation to music for a legged robot*, in 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), oct 2018, pp. 1038–1044.

[9] M. Bjelonic, C. D. Bellicoso, Y. de Viragh, D. Sako, F. D. Tresoldi, F. Jenelten, and M. Hutter, *Keep rollin'- whole-body motion control and planning for wheeled quadrupedal robots*, IEEE Robotics and Automation Letters, (2019).

[10] M. Bjelonic, C. D. Bellicoso, M. E. Tiryaki, and M. Hutter, *Skating with a force controlled quadrupedal robot*, in IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018, pp. 7555–7561.

[11] M. Bjelonic, P. K. Sankar, C. D. Bellicoso, H. Vallery, and M. Hutter, *Rolling in the deep – hybrid locomotion for wheeled-legged robots using online trajectory optimization*, IEEE Robotics and Automation Letters, 5 (2020), pp. 3626–3633.

[12] M. Bloesch, H. Sommer, T. Laidlow, M. Burri, G. Nützi, P. Fankhauser, C. D. Bellicoso, C. Gehring, S. Leutenegger, M. Hutter, and R. Siegwart, *A primer on the differential calculus of 3d orientations*, CoRR, abs/1606.05285 (2016).

[13] K. Bodie, C. D. Bellicoso, and M. Hutter, *Anypulator: Design and control of a safe robotic arm*, in Intelligent Robots and Systems (IROS), 2016 IEEE/RSJ International Conference on, IEEE, 2016, pp. 1119–1125.

[14] Y. de Viragh, M. Bjelonic, C. D. Bellicoso, F. Jenelten, and M. Hutter, *Trajectory optimization for wheeled-legged quadrupedal robots using linearized zmp constraints*, IEEE Robotics and Automation Letters, 4 (2019), pp. 1633–1640.

[15] P. Fankhauser, C. D. Bellicoso, C. Gehring, R. Dubé, A. Gawel, and M. Hutter, *Free gait—an architecture for the versatile control of legged robots*, in International Conference on Humanoid Robots (Humanoids), 2016 IEEE-RAS 16th, IEEE, 2016, pp. 1052–1058.

[16] P. Fankhauser, M. Bjelonic, C. D. Bellicoso, T. Miki, and M. Hutter, *Robust rough-terrain locomotion with a quadrupedal robot*, in IEEE International Conference on Robotics and Automation (ICRA), 2018.

[17] C. Gehring, C. D. Bellicoso, S. Coros, M. Bloesch, P. Fankhauser, M. Hutter, and R. Siegwart, *Dynamic trotting on slopes for quadrupedal robots*, in International Conference on Intelligent Robots and Systems (IROS), 2015 IEEE/RSJ, IEEE, 2015, pp. 5129–5135.

[18] C. Gehring, C. D. Bellicoso, P. Fankhauser, S. Coros, and M. Hutter, *Quadrupedal locomotion using trajectory optimization and hierarchical whole body control*, in International Conference on Robotics and Automation (ICRA), 2017 IEEE, IEEE, 2017, pp. 4788–4794.

[19] C. Gehring, S. Coros, M. Hutter, C. D. Bellicoso, H. Heijnen, R. Diethelm, M. Bloesch, P. Fankhauser, J. Hwangbo, M. Hoepflinger, et al., *Practice makes perfect: An optimization-based approach to controlling agile motions for a quadruped robot*, IEEE Robotics & Automation Magazine, 23 (2016), pp. 34–43.

[20] M. Hutter, C. Gehring, D. Jud, A. Lauber, C. D. Bellicoso, V. Tsounis, J. Hwangbo, K. Bodie, P. Fankhauser, M. Bloesch, et al., *Anymal-a highly mobile and dynamic quadrupedal robot*, in 2016 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), IEEE, 2016, pp. 38–44.

[21] M. Hutter, C. Gehring, A. Lauber, F. Gunther, C. D. Bellicoso, V. Tsounis, P. Fankhauser, R. Diethelm, S. Bachmann, M. Blösch, H. Kolvenbach, M. Bjelonic, et al., *Anymal-toward legged robots for harsh environments*, Advanced Robotics, (2017), pp. 918–931.

[22] J. Hwangbo, C. D. Bellicoso, P. Fankhauser, and M. Hutter, *Probabilistic foot contact estimation by fusing information from dynamics and differential/forward kinematics*, in International Conference on Intelligent Robots and Systems (IROS), 2016 IEEE/RSJ, IEEE, 2016, pp. 3872–3878.

[23] J. Hwangbo, C. Gehring, C. D. Bellicoso, P. Fankhauser, R. Siegwart, and M. Hutter, *Direct state-to-action mapping for high dof robots using elm*, in 2015 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), sep 2015, pp. 2842–2847.

[24] J. Hwangbo, J. Lee, A. Dosovitskiy, C. D. Bellicoso, V. Tsounis, V. Koltun, and M. Hutter, *Learning agile and dynamic motor skills for legged robots*, Science Robotics, 4 (2019).

[25] F. Jenelten, J. Hwangbo, F. Tresoldi, C. D. Bellicoso, and M. Hutter, *Dynamic locomotion on slippery ground*, IEEE Robotics and Automation Letters, 4 (2019), pp. 4170–4176.

[26] H. Kolvenbach, C. D. Bellicoso, F. Jenelten, L. Wellhausen, and M. Hutter, *Efficient gait selection for quadrupedal robots on the moon and mars*, in 14th International Symposium on Artificial Intelligence, Robotics and Automation in Space (i-SAIRAS 2018), ESA Conference Bureau, 2018.

[27] M. Neunert, M. Stäuble, M. Giftthaler, C. D. Bellicoso, J. Carius, C. Gehring, M. Hutter, and J. Buchli, *Whole-body nonlinear model predictive control through contacts for quadrupeds*, IEEE Robotics and Automation Letters, 3 (2018), pp. 1458–1465.

[28] A. W. Winkler, C. D. Bellicoso, M. Hutter, and J. Buchli, *Gait and trajectory optimization for legged systems through phase-based end-effector parameterization*, IEEE Robotics and Automation Letters, 3 (2018), pp. 1560–1567.

Awards

Best Paper Award — *Madrid, Spain*

JTCF Novel Technology Paper Award for Amusement Culture — *October 2018*

"Real-Time Dance Generation to Music for a Legged Robot", Thomas Bi, Péter Fankhauser, C. Dario Bellicoso, Marco Hutter

Best Paper Award — *Singapore*

IEEE Robotics and Automation Magazine Best Paper Award 2017 — *May-June 2017*

"Practice Makes Perfect: An Optimization-Based Approach to Controlling Agile Motions for a Quadruped Robot", Christian Gehring, Stelian Coros, Marco Hutter, C. Dario Bellicoso, Huub Heijnen, Remo Diethelm, Michael Bloesch, Péter Fankhauser, Jemin Hwangbo, Mark Hoepflinger and Roland Siegwart

Best Paper Award — *Daejeon, South Korea*

IROS Best Paper Award — *October 2016*

"ANYmal - a Highly Mobile and Dynamic Quadrupedal Robot", Marco Hutter, Christian Gehring, Dominic Jud, Andreas Lauber, Carmine Dario Bellicoso, Vassilios Tsounis, Jemin Hwangbo, Karen Bodie, Péter Fankhauser, Michael Bloesch, Remo Diethelm, Samuel Bachmann, Amir Melzer, Mark Hoepflinger

Conferences and Presentations

ICRA 2019 — *Montreal, Canada*

Conference — *May 2019*

- Poster for the accepted ICRA paper "ALMA-Articulated Locomotion and Manipulation for a Torque-Controllable Robot".
- Invited workshop talk on control of redundant robots.
- `https://youtu.be/XrcLXX4AEWE`

Massachusetts Institute of Technology (MIT) — *Cambridge, MA*

Seminar on robotic legged locomotion and manipulation — *December 2018*

- Presentation on robotic legged locomotion and manipulation.

University of Technology Sydney — *Sydney, Australia*

Invited lecture on legged locomotion and manipulation — *May 2018*

- Presentation on the latest research on legged locomotion and manipulation done by the Robotic Systems Lab, ETH Zurich.

ICRA 2018 — *Brisbane, Australia*

Conference — *May 2018*

- Poster for the accepted RA-L paper "Dynamic Locomotion Through Online Nonlinear Motion Optimization for Quadrupedal Robots".
- `https://youtu.be/Gvcvs80yZvU`

IROS 2017 — *Vancouver, Canada*

Conference — *September 2017*

- Presentation for the accepted conference paper "Dynamic locomotion and whole-body control for quadrupedal robots".
- `https://youtu.be/iUQE-ZQqdJY`

Humanoids 2016 — *Cancun, Mexico*

Conference — *November 2016*

- Poster for the accepted paper "Perception-less terrain adaptation through whole body control and hierarchical optimization".
- `https://youtu.be/AjiLCbJUYKI`

Patents

Systems and methods for grasp planning for a robotic manipulator — *USA*

Patent pending — *June 2023*

Samuel Shaw, Logan W. Tutt, Shervin Talebi, C. Dario Bellicoso, Jennifer Barry, Neil M. Neville

Nonlinear trajectory optimization for robotic devices — *USA*

Patent pending — *April 2023*

C. Dario Bellicoso, Logan W. Tutt, Neil M. Neville, Alexander D. Perkins