# Mattia Piccinini

TUM Global Post-doctoral Fellow in Autonomous Ground Robotics
Technical University of Munich (TUM), Germany

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## Research Interests

My research lies at the intersection of **robotics**, **machine learning**, and **control** engineering. I develop algorithms for real-time trajectory planning, control, and estimation of autonomous robots, with a focus on **ground vehicles** in uncertain, dynamic environments. I like to integrate prior knowledge of the robot dynamics into learning-based methods, such as neural networks, to enhance their **generalization to unseen scenarios** with minimal training data.

## Education

11/2019 – 04/2024 — **Ph.D. in Autonomous Systems**, University of Trento, Italy
Doctorate awarded with highest distinction (*summa cum laude*)
Ph.D. thesis: *Artificial Drivers for Online Time-Optimal Vehicle Trajectory Planning and Control*
Supervisor: Prof. Francesco Biral
Date of the defense: 12/04/2024

09/2017 – 10/2019 — **M.Sc. in Mechatronics Engineering**, University of Trento, Italy
Final grade: 110/110 *summa cum laude*
GPA: 30/30, 80% exams with maximum score, 60% exams passed with honors
Thesis: *Path planning and control of self-driving vehicles at the limits of handling* [pdf].

09/2014 – 09/2017 — **B.Sc. in Industrial Engineering**, University of Trento, Italy
Final grade: 110/110 *summa cum laude*
GPA: 30/30, 90% exams with maximum score, 60% exams passed with honors
Thesis: *Degradation of glycol-based cooling fluids causing corrosion in machine tools refrigeration circuits*. The thesis was carried out in cooperation with the companies Pama S.p.A. and Rittal GmbH.

09/2009 – 06/2014 — **Scientific High School Diploma**
Liceo Scientifico A. Rosmini, Rovereto, Italy
Final grade: 100/100

## Research Experience

12/2024 – present — **TUM Global Post-doctoral Fellow**
Technical University of Munich, Munich, Germany
Supervisor: Prof. Johannes Betz

04/2024 – 11/2024 — **Post-doctoral Researcher**
University of Trento, Trento, Italy
Supervisor: Prof. Francesco Biral

03/2022 – 06/2022 — **Visiting Ph.D. Student**
Universität der Bundeswehr, Munich, Germany
Supervisor: Prof. Matthias Gerdts

## Teaching and Supervision Experience

07/2025 – present
**Teaching Assistant**, Technical University of Munich, Germany
Courses of:
- *Ethical Robot Systems*
- *Autonomous Vehicles: Motion Planning and Decision Making*

Tasks: Exam preparation and correction.

09/2021 – 02/2022
09/2020 – 02/2021
11/2019 – 02/2020
**Teaching Assistant**, EIT Digital Master School, University of Trento, Italy
Course of *Vehicle Dynamics, Planning and Control of Robotic Cars*.
- Preparation of lecture slides and assignments.
- Holding lectures and exercise sessions.
- Grading assignments and providing feedback to students.

03/2025 – 02/2026
**Program Assistant**, Robotics Institute Germany, Germany
Assistance in the creation of a new Master of Science in AI-based Robotics.
- Definition of requirements from the industry and research community.
- Analysis on the educational programs in robotics at national level.

2025 – present
**Thesis Co-Supervisor**, Technical University of Munich, Germany
- 7 Ph.D. Students
- 5 Master Students
- 2 Visiting Ph.D. Students

2019 – present
**Thesis Co-Supervisor**, University of Trento, Italy
- 1 Ph.D. Student
- 9 Master Students

2021 – 2022
**Thesis Co-Supervisor**, EIT Digital Master School (EU)
- 1 Master Student
- 1 Term Project

2020 – 2021
**Thesis Co-Supervisor**, HAN University of Applied Sciences, Netherlands
- 1 Master Student

## Work Experience

09/2018 – 06/2019
**Control and Simulation Engineer**
Formula SAE Project, Dynamics and Modeling Team, University of Trento, Italy
- Development of vehicle multibody models to validate vehicle controllers.
- Parameter optimization for the mechatronic powertrain.

09/2017 – 07/2018
**Mechanical Design Engineer**
Formula SAE Project, Powertrain Design Team, University of Trento, Italy
- Responsible for the mechanical transmission unit.

06/2016 – 08/2017
**Cooling System Engineer**
Formula SAE Project, Cooling System Design Team, University of Trento, Italy
- Design and manufacturing of the cooling system for an electric FSAE vehicle.

08/2018 – 09/2018
**Engineering Internship**
Pama S.p.A., Rovereto (Italy)
- Design of innovative solutions for the kinematic chain in a large-scale, high-precision milling machine divider.

09/2016
**Engineering Internship**
Pama S.p.A., Rovereto (Italy)
- Experimental setup to investigate corrosion phenomena arising from the degradation of glycol-based cooling fluids within machine tool circuits.

## Work Experience (continued)

02/2016
09/2015
02/2015

**Engineering Internship**
Pama S.p.A., Rovereto (Italy)

- Design and analysis of mechanical and hydraulic assemblies for large-scale high-precision milling and boring machine tools.

## Publications and Patents

### Peer-Reviewed Journal Papers

1. M. Piccinini, S. Taddei, M. Larcher, M. Piazza, and F. Biral, "A physics-driven artificial agent for online time-optimal vehicle motion planning and control," *IEEE Access*, vol. 11, pp. 46 344–46 372, 2023. DOI: 10.1109/ACCESS.2023.3274836.
2. M. D. Lio, M. Piccinini, and F. Biral, "Robust and sample-efficient estimation of vehicle lateral velocity using neural networks with explainable structure informed by kinematic principles," *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–15, 2023. DOI: 10.1109/TITS.2023.3303776.
3. M. Piccinini, M. Larcher, E. Pagot, D. Piscini, L. Pasquato, and F. Biral, "A predictive neural hierarchical framework for on-line time-optimal motion planning and control of black-box vehicle models," *Vehicle System Dynamics*, vol. 61, no. 1, pp. 83–110, 2023. DOI: 10.1080/00423114.2022.2035776. eprint: https://doi.org/10.1080/00423114.2022.2035776.
4. E. Pagot, M. Piccinini, E. Bertolazzi, and F. Biral, "Fast planning and tracking of complex autonomous parking maneuvers with optimal control and pseudo-neural networks," *IEEE Access*, vol. 11, pp. 124 163–124 180, 2023. DOI: 10.1109/ACCESS.2023.3330431.
5. M. Piccinini, S. Taddei, E. Pagot, E. Bertolazzi, and F. Biral, "How optimal is the minimum-time manoeuvre of an artificial race driver?" *Vehicle System Dynamics*, vol. 63, no. 12, pp. 2213–2240, 2025. DOI: 10.1080/00423114.2024.2407176.
6. M. Piccinini, M. Zumerle, J. Betz, and G. Pietro Rosati Papini, "A road friction-aware anti-lock braking system based on model-structured neural networks," *IEEE Open Journal of Intelligent Transportation Systems*, vol. 6, pp. 522–536, 2025. DOI: 10.1109/OJITS.2025.3563347.
7. A. Langmann, S. Kohl, L. Ögretmen, M. Piccinini, and J. Betz, "A multi-stage time-variant motion planner for agile autonomous driving maneuvers," *IEEE Open Journal of Intelligent Transportation Systems*, 2025, under review.
8. M. Piazza, M. Piccinini, S. Taddei, F. Biral, and E. Berolazzi, "Real-time velocity profile optimization for time-optimal maneuvering with generic acceleration constraints," *IEEE Robotics and Automation Letters*, vol. 11, no. 2, pp. 1674–1681, 2026. DOI: 10.1109/LRA.2025.3643297.
9. D. Wang, R. Brusnicki, Z. Lai, Y. Wu, M. Piccinini, R. Yang, W. Li, and J. Betz, "Extrospective prediction for autonomous driving in emergency cut-in scenarios," *IEEE Transactions on Intelligent Transportation Systems*, 2025, under review.
10. F. Jahncke, B. Zarrouki, M. Piccinini, S. Bae, J. D'sa, D. Isele, and J. Betz, "Differentiable weights-varying nonlinear mpc via gradient-based policy learning: An autonomous vehicle guidance example," *IEEE Robotics and Automation Letters*, 2025, under review.
11. S. Goblirsch, M. Piccinini, J. Betz, and M. Lienkamp, "Multidirectional gaussian-process tire models for kalman filtering in vehicle dynamics state estimation," *Vehicle System Dynamics*, 2025, under review.
12. A. Mungiello, F. Jahncke, S. Santini, J. Betz, G. P. R. Papini, and M. Piccinini, "Model-structured neural networks for vehicle dynamics learning near the limits," *IEEE Open Journal of Intelligent Transportation Systems*, 2026, under review.

13. Z. Li, B. Zhou, C. Hu, M. Piccinini, B. Zarrouki, R. Mengharam, and L. Xie, "Evo-mpcc: Enhanced velocity optimizationwith learning-based auto-tuning for real-time vehicle trajectory planning," *Robotics and Autonomous Systems*, 2026, under review.

14. M. Piccinini, S. Gottschalk, M. Gerdts, and F. Biral, "Computationally efficient minimum-time motion primitives for vehicle trajectory planning," *IEEE Open Journal of Intelligent Transportation Systems*, vol. 5, pp. 642–655, 2024. DOI: 10.1109/OJITS.2024.3476540.

15. Y. Gao, M. Piccinini, Y. Zhang, D. Wang, K. Moller, R. Brusnicki, B. Zarrouki, A. Gambi, J. F. Totz, K. Storms, S. Peters, A. Stocco, B. Alrifaee, M. Pavone, J. Betz, "Foundation models in autonomous driving: A survey on scenario generation and scenario analysis," *IEEE Open Journal of Intelligent Transportation Systems*, 2025, under review.

## Peer-Reviewed Conference Papers

1. E. Pagot, M. Piccinini, and F. Biral, "Real-time optimal control of an autonomous rc car with minimum-time maneuvers and a novel kineto-dynamical model," in *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2020, pp. 2390–2396. DOI: 10.1109/IROS45743.2020.9340640.

2. M. Piccinini, S. Taddei, J. Betz, and F. Biral, "Kineto-dynamical planning and accurate execution of minimum-time maneuvers on three-dimensional circuits," in *2025 IEEE International Conference on Robotics and Automation (ICRA)*, 2025, pp. 1–7. DOI: 10.1109/ICRA55743.2025.11127446.

3. M. Kaufeld, M. Piccinini, and J. Betz, "Mp-rbfn: Learning-based vehicle motion primitives using radial basis function networks," in *IEEE Intelligent Transportation Systems Conference (ITSC)*, accepted, 2025.

4. Y. Gao, M. Piccinini, K. Moller, A. Alanwar and J. Betz, "From words to collisions: Llm-guided evaluation and adversarial generation of safety-critical driving scenarios," in *IEEE Intelligent Transportation Systems Conference (ITSC)*, accepted, 2025.

5. M. Piccinini, A. Mungiello, G. Jank, G. P. R. Papini, and J. Betz, "Model-structured neural networks to control the steering dynamics of autonomous race cars," in *IEEE Intelligent Transportation Systems Conference (ITSC)*, accepted, 2025.

6. R. Brusnicki, M. Piccinini, and J. Betz, "Venuss: Vlm evaluation for navigational understanding of sequential scenes," in *IEEE/CVF Winter Conference on Applications of Computer Vision (WACV)*, under review, 2025.

7. F. Werner, S. Sagmeister, M. Piccinini, and J. Betz, "A quasi-steady-state black box simulation approach for the generation of g-g-g-v diagrams," in *2025 IEEE Intelligent Vehicles Symposium (IV)*, 2025, pp. 2503–2509. DOI: 10.1109/IV64158.2025.11097491.

8. B. Zhou, B. Zarrouki, M. Piccinini, C. Hu, L. Xie, and J. Betz, "Safe reinforcement learning with a predictive safety filter for motion planning and control: A drifting vehicle example," in *2025 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2025, pp. 4196–4203. DOI: 10.1109/IROS60139.2025.11246272.

9. S. Taddei, M. Piccinini, and F. Biral, "Biasing the driving style of an artificial race driver for online time-optimal maneuver planning," in *2025 IEEE Intelligent Vehicles Symposium (IV)*, 2025, pp. 640–647. DOI: 10.1109/IV64158.2025.11097381.

10. S. Gottschalk, M. Gerdts, and M. Piccinini, "Reinforcement learning and optimal control: A hybrid collision avoidance approach," in *Proceedings of the 10th International Conference on Vehicle Technology and Intelligent Transport Systems - VEHITS*, INSTICC, SciTePress, 2024, pp. 76–87, ISBN: 978-989-758-703-0. DOI: 10.5220/0012569800003702.

11. M. Piazza, M. Piccinini, S. Taddei, and F. Biral, "Mptree: A sampling-based vehicle motion planner for real-time obstacle avoidance," 10, 17th IFAC Symposium on Control of Transportation Systems CTS 2024, vol. 58, 2024, pp. 146–153. DOI: https://doi.org/10.1016/j.ifacol.2024.07.332.

12. M. Piccinini, S. Taddei, M. Piazza, and F. Biral, "Impacts of g-g-v constraints formulations on online minimum-time vehicle trajectory planning," 10, 17th IFAC Symposium on Control of Transportation Systems CTS 2024, vol. 58, 2024, pp. 87–93. DOI: https://doi.org/10.1016/j.ifacol.2024.07.323.

## Peer-Reviewed Workshop Papers

1. E. Pagot, M. Piccinini, A. Plebe, E. Bertolazzi, and F. Biral, "Real-time autonomous parking in unstructured scenarios with an indirect optimal control approach," in *Workshop Behavior-Driven Autonomous Driving in Unstructured Environments (BADUE), IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, 2022. URL: https://obj.umiacs.umd.edu/badue-accepted/8.pdf.
2. M. Piccinini, S. Gottschalk, M. Gerdts, and F. Biral, "Neural motion primitives for online time-optimal vehicle trajectory planning," in *Conference AUTOMATICA.IT*, 2024.
3. M. Piccinini, M. Zumerle, J. Betz, and G. P. R. Papini, "Model-structured neural networks for road friction-aware anti-lock braking systems," in *Conference AUTOMATICA.IT*, 2025.
4. S. Taddei, M. Piccinini, and F. Biral, "From early to late apexes: Biasing the driving style of online time-optimal maneuver planning," in *Conference AUTOMATICA.IT*, 2025.
5. S. Taddei, M. Piccinini, E. Pagot, and F. Biral, "Artificial racing coach: Teaching humans how to maximize a racing vehicle's performance and drive at its limits," in *Conference AUTOMATICA.IT*, 2024.
6. M. Piccinini, S. Taddei, M. Larcher, M. Piazza, and F. Biral, "A physics-driven framework for online minimum-time vehicle motion planning and control," in *Conference AUTOMATICA.IT*, 2023.

## Other Publications

1. M. Piccinini and S. Mariano, "Localization and control of autonomous vehicles in an urban intersection scenario," 2019. URL: https://www.researchgate.net/publication/334945954_Localization_and_Control_of_Autonomous_Vehicles_in_an_Urban_Intersection_Scenario.

## Invited Talks, Presentations and Poster Sessions

1. M. Piccinini, E. Pagot, and S. Taddei, "Virtual Driver to Control Race Cars near the Limits", *PhDII Poster Session*, University of Trento, 2022.
2. M. Piccinini, "Physics-Guided Motion Generation and Control: From Autonomous Racing Towards General Robotics", *Invited Talk*, Eindhoven University of Technology, 2025.
3. M. Piazza and M. Piccinini, "MPTree: Motion Primitive Tree Exploration for Trajectory Planning with Dynamic Obstacle Avoidance", *Poster Session at the Industrial Engineering Day*, University of Trento, 2022.
4. M. Piccinini, S. Taddei, and F. Biral, "Artificial Race Driver", *Poster Session at the Industrial Engineering Day*, University of Trento, 2023.
5. M. Piccinini, "Virtual race drivers for planning and control with robotic cars", *Seminar at the Engineering Mathematics Days*, Universität der Bundeswehr, Munich, 2022.
6. M. Piccinini, A. Mungiello, J. Betz, and G. P. R. Papini, "Model-Structured Neural Networks to Model & Control Robots", *Late-Breaking Results Poster Session*, International Conference on Robotics and Automation (ICRA), Atlanta, USA, 2025.
7. M. Piccinini and G. P. R. Papini, "NNodely: An Open Framework for Model-Structured Neural Networks in Robotics", *Invited talk*, Workshop series organized by the Ekumen company, 2025.
8. M. Piccinini, "Artificial Drivers to Learn the Vehicle Dynamics, Plan and Execute Online Time-Optimal Maneuvers", *Seminar*, Technical University of Munich, 2024.

9. M. Piccinini and G. P. R. Papini, "Model-Structured Neural Networks to Model and Control Physical Systems", *Seminar for PhD students*, University of Trento, 2024.

10. M. Piccinini, "Model-Structured Neural Networks to Model and Control Vehicles and Robots", *Doktorandenkolloquium Seminar*, Technical University of Munich, Berchtesgaden, 2025.

### Patents

1. M. D. Lio, F. Biral, and M. Piccinini, "Device and method, based on neural networks, for estimating the lateral speed of vehicles", WO2023166536A1, 2023. URL: https://patents.google.com/patent/WO2023166536A1/en?oq=PCT%2fIT2023%2f050058.

## Awards & Funding

12/2025 **Humboldt Post-doctoral Fellowship**
2-year funding for post-doctoral researchers, following the evaluation of a research proposal (**success rate** $< 20\%$).

**Best Poster Award**
German Autonomy Summit, Munich (Germany), 2025 ($3^{\text{rd}}$ place).

10/2025 **Best Workshop Paper Award**
2025 IEEE IROS conference, Workshop on Planning, Perception and Navigation for Intelligent Vehicles.

09/2025 **Best Ph.D. Thesis Award**
Issued by the journal *MDPI Vehicles*.

08/2025 **IEEE ITSS Best Dissertation Award**
Issued by the IEEE Intelligent Transportation Systems Society.

**IEEE IES-SYPA Travel Award**
Issued by the IEEE Industrial Electronics Society (IES) for participation in the 2025 IEEE IROS conference (**success rate** $< 10\%$).

06/2025 **Best Paper Award Finalist**
2025 IEEE Intelligent Vehicles (IV) Symposium.

03/2025 **EuroTech Visiting Researcher Award**
15-day research travel grant to collaborate with the Eindhoven University of Technology, following a competitive selection of a research proposal.

12/2024 **TUM Global Post-doctoral Fellowship**
2-year funding for early-career researchers, following the evaluation of a research proposal (10 funded positions, **success rate** $< 10\%$).

07/2024 **IFAC Young Author Award**
Awarded at the $17^{\text{th}}$ IFAC Symposium on Control in Transportation Systems, Cyprus.

05/2024 **Best Paper Award Finalist**
$10^{\text{th}}$ International Conference on Vehicle Technology and Intelligent Transport Systems (VEHITS).

04/2024 **Ph.D. Graduation with Highest Distinction** (*summa cum laude*)

11/2023 **Best Poster Award**
Industrial Engineering Day, University of Trento (Italy).

10/2019 **M.Sc. Graduation with Highest Distinction** (*summa cum laude*)

09/2017 **B.Sc. Graduation with Highest Distinction** (*summa cum laude*)

## Academic Service

### Peer-Review Activities

**Journals**: IEEE Transactions on Intelligent Transportation Systems; IEEE Transactions on Vehicular Technology; IEEE Transactions on Mechatronics; IEEE Transactions on Industrial Electronics; IEEE Open Journal of Control Systems; IEEE Transactions on Control Systems Technology; IEEE Transactions on Robotics; IEEE Robotics and Automation Letters (RA-L); IEEE Access; Vehicle System Dynamics; Springer Nature - International Journal of Machine Learning and Cybernetics; Springer Optimization and Engineering; Springer Nature Communications; Mechanical Systems and Signal Processing; MDPI Vehicles; MDPI Machines; MDPI Electronics; MDPI Actuators; MDPI Drones; MDPI Symmetry; MDPI Applied Sciences; MDPI World Electric Vehicle Journal

**Conferences**: IEEE International Conference on Robotics and Automation (ICRA); IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS); IEEE Intelligent Vehicles Symposium (IV); IEEE International Conference on Intelligent Transportation Systems (ITSC); IEEE Conference on Decision and Control (CDC); IEEE Conference on Control Technology and Applications; IEEE International Conference on Real-time Computing and Robotics; IEEE International Conference on Advanced Motion Control; International Conference on System Theory, Control and Computing (ICSTCC); IFAC Symposium on Control in Transportation Systems.

### Conference Committees

- **Chair** of the session "Path Planning", at the Automatica.it conference, Bolzano (Italy), 2024
- **Co-chair** of the session "Modeling, Control, and Optimization of Transportation Systems", at the 17th IFAC Symposium on Control in Transportation Systems (CTS), Ayia Napa (Cyprus), 2024

## Skills

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|---|---|
| Programming | Matlab, Simulink, Python, C/C++, Maple, Mathematica, Ruby |
| Machine Learning Frameworks | Tensorflow, Keras, PyTorch |
| Development Tools | GitHub, GitLab, Bitbucket |
| CAD Software | SolidWorks, Inventor, AutoCAD |
| Operating Systems | MacOS, Windows, Linux |
| Other Computer Skills | LaTeX, Microsoft Word, Microsoft Excel, Microsoft Power-Point, Apple Keynote, Apple Pages |
| Others | Driving licence B |
| Languages | English: full professional proficiency (Cambridge Certificate of Advanced English, level C1)<br>German: upper-intermediate knowledge<br>Italian: native |

## Personal Details and Interests

- Date of birth: 16/07/1995
- Nationality: Italian
- Personal interests: traveling, swimming, hiking

## References

- Prof. Johannes Betz, Technische Universität München, München (Germany),
  phone: +49 89 289 10407, email: johannes.betz@tum.de
- Prof. Francesco Biral, University of Trento, Trento (Italy),
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- Prof. Matthias Gerdts, Universität der Bundeswehr, München (Germany),
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- Prof. Mauro Da Lio, University of Trento, Trento (Italy),
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- Prof. Gastone Pietro Rosati Papini, University of Trento, Trento (Italy),
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*Munich, 31/12/2025*

Mattia Piccinini