Matías Mattamala

Curriculum Vitae

Contact Information

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Research Overview

I aim to make robots that help us understand and solve problems of the real world. To achieve this, my research focuses on the foundations and systems for lifelong autonomy: representations and algorithms for perception, learning, and action that enable autonomous and adaptive behaviour in robots working with humans or alone in the wild.

Current Positions

University of Edinburgh, Edinburgh, UK
Research Associate — Jun 2025 – present

- Member of the Centre for AI for Assistive Autonomy led by Prof. Subramanian Ramamoorthy.
- Lead of the Assistive Care team.
- Researching scene representations for human-robot interaction.
- Lab management, robot maintenance, student supervision, dissemination.

Education

University of Oxford, Oxford, UK
DPhil in Engineering Science — Oct 2019 – Nov 2023
"Vision-based Legged Robot Navigation: Localisation, Local Planning, Learning"
Supervisor: Prof. Maurice Fallon

Universidad de Chile, Santiago, Chile
M.Sc in Electrical Engineering — Mar 2015 – Aug 2018
"Visual Localisation for Resource-constrained Robots"
Supervisor: Prof. Javier Ruiz-del-Solar

Ingeniería Civil Eléctrica — Mar 2009 – Aug 2018
B.Sc in Electrical Engineering — Mar 2009 – Mar 2014

Past Positions

University of Oxford, Oxford, UK
Postdoctoral Researcher — Sep 2023 – May 2025

- Research on robot navigation and mapping using vision, geometry, and language under Prof. Maurice Fallon.
- Supervision of PhD students, student visitors, and undergraduate students.
- Lab management, grant application writing, dissemination, field trials.

ETH Zürich, Zürich, Switzerland
Visiting Researcher — Apr 2022 – Sep 2022

- Research visit at the Robot Systems Lab (RSL) under Prof. Marco Hutter.
- Project on learned visual traversability estimation for natural environments.
- Co-supervision of semester and master's thesis projects.

Universidad de Chile, Santiago, Chile
Project Manager — Jun 2018 – Aug 2019

- Coordination of the 'Beauchef Proyecta' unit to foster multidisciplinary activities across engineering degrees. Managed funds associated to the project (∼£90,000).

Undergraduate and M.Sc. researcher — Mar 2012 – Aug 2018
- Perception lead of the UChile Robotics RoboCup Soccer team. Joined competitions in Mexico (2012), The Netherlands (2013), Brazil (2014, 4th place), and China (2015, 4th place).

Knight Robotics, Santiago, Chile
Part-time Developer — Jan 2015 – Mar 2018
- Assembly of educational robot kits, graphic design, training for school teachers.

ALMA Observatory, San Pedro de Atacama, Chile
Engineering Intern — Jan 2013 – Mar 2013
- Implementation of graphical user interfaces for monitoring the radiotelescope's antennas.

Teaching

University of Oxford, Oxford, UK
Teaching Assistant — Mar 2021
- Lead TA of an AIMS CDT course on autonomous exploration. I co-designed a new online challenge (due to COVID-19 restrictions) to introduce advanced robotics methods and C++ programming.

Universidad de Chile, Santiago, Chile
Instructor — Mar 2017 – Sep 2019
- Designed and taught courses on mobile robotics (based on the Duckietown project), tech project development, battlebots, and data science for astronomy. Over 300 students taught.

Teaching Assistant — Mar 2012 – Dec 2016
- TA for mobile robotics, image processing, computational methods for science and engineering, introduction to engineering, and electromagnetism. Over 200 students taught.

Mustakis Foundation, Santiago, Chile
Instructor — Apr 2014 – Jun 2018
- Introductory robotics and programming courses for high school students using LEGO Mindstorms and Arduino. Over 200 high-school students taught.

Selected Publications
(*equal contribution)

[3] **Matías *Mattamala**, Jonas *Frey, Piotr Libera, Nived Chebrolu, Georg Martius, Cesar Cadena, Marco Hutter and Maurice Fallon. July 2025. "Wild Visual Navigation: Fast Traversability Learning via Pre-Trained Models and Online Self-Supervision". *Autonomous Robots*. **Invited paper**.

[2] **Matías Mattamala**, Nived Chebrolu, Jonas Frey, Leonard Freißmuth, Haedam Oh, Benoit Casseau, Jonas Frey, Marco Hutter and Maurice Fallon. June 2025. "Building Forest Inventories with Autonomous Legged Robots — System, Lessons, and Challenges Ahead". *IEEE Trans. Field Robotics*. **Invited paper**.

[1] Christina Kassab, **Matías Mattamala**, Lintong Zhang and Maurice Fallon. May 2024. "Language-EXtended Indoor SLAM (LEXIS): A Versatile System for Real-time Visual Scene Understanding". *IEEE Int. Conf. Robot. Autom. (ICRA)*.

Invited Talks

Robot Perception for Real-world Autonomy
International Workshop of Intelligent Autonomous Learning Systems (IWIALS) 2025, Austria. Jul 2025. slides
Universidad del Desarrollo, Chile. May 2025.
ICRA 2025 LA@Chile Satellite, Universidad de Chile, Chile. May 2025.

Effective Design of Graphics for (Robotics) Research
International Workshop of Intelligent Autonomous Learning Systems (IWIALS) 2025, Austria. July 2025. slides
ICRA 2025 LA@Chile Satellite, Universidad de Chile, Chile. May 2025. slides
Oxford Robotics Institute, University of Oxford, UK. Apr 2025. slides

From Industrial Facilities to Forestry Applications: ANYmal Research at the University of Oxford
Institution of Engineering and Technology (IET) (Invited talk by ANYbotics AG). Sep 2024. video, slides

DigiForest: Developing Robotic Technologies for Sustainable Forestry
ForestryAI Webinar, Jul 2024. video, slides

Visual Navigation for Legged Robots in Challenging Environments
Qué hacemos en robótica? (Spanish), Universidad de Chile, Chile. Feb 2023.
Técnicas modernas de control y aprendizaje de máquina para robótica y locomoción (Spanish), Universidad Nacional de Colombia, Colombia. Feb 2023. slides
AIMS-WASP Event, University of Oxford, UK. Oct 2022. slides

On Physical, Algebraic, Geometric, and Probabilistic Descriptions in Robotics
RPL Robotics Seminar, University College London, UK. Oct 2021. slides

Visual Navigation for Quadrupedal Robots
Charlas en AI, Robótica, Tecnología y Aplicaciones (Spanish), Universidad de O'Higgins, Chile. Jul 2021. slides
IEEE UPAO Webinar (Spanish), Universidad Privada Antenor Orrego, Perú. Apr 2022. slides

Robot Soccer
Futuristas, el mundo cambia contigo (Spanish), National Congress of Chile, Chile. Nov 2016. video, slides

Supervision and Co-Supervision

University of Edinburgh

- Heramb Modugula, PhD project (2025 – present). Topic: "Personalisation in Visual-Language-Action Models". *Co-supervisor*
- Aiden Lyons, Honours Project (2025 – present). Topic: "Force-controlled Visual-Language-Action models". *Co-supervisor*
- Tianqi Zhu, Honours Project (2025 – present). Topic: "Contact-Rich Reinforcement Learning". *Co-supervisor*

University of Oxford

- Jin Jin, PhD project (2025 – present). Topic: "Robot Social Navigation with Foundation Models". *Co-supervisor*
- Haedam Oh, 4th Year Project (2023). Topic: "Evaluation and Deployment of LiDAR-based Place Recognition in Dense Forests". *Co-supervisor*

- Leonard Freißmuth, M.Sc Visitor (2023). Topic: "Online Tree Reconstruction and Forest Inventory on a Mobile Robotic System". *Co-supervisor*
- Jianeng Wang, PhD project (2023 – 2025). Topic: "Vision-centric State Estimation and Mapping for Visually Challenging scenarios". *Co-supervisor*
- Christina Kassab, PhD project (2022 – present). Topic: "Language-Extended Visual SLAM for Real-time Scene Understanding". *Co-supervisor*

ETH Zürich

- Piotr Libera, Semester Project (2023). Topic: "Semantic Understanding of Outdoor Environments for Navigation". *Co-supervisor*
- Giacomo Manzoni, Semester Project (2022). Topic: "Motion-primitives Planning for Legged Robots". *Co-supervisor*
- Pascal Lieberherr, M.Sc Thesis (2022). Topic: "Local Path Planning in Orchards and Vineyards". *Co-supervisor*
- Timo Schönegg, M.Sc Thesis (2022). Topic: "Global Planning in Orchards and Vineyards". *Co-supervisor*

Universidad de Chile

- Andrés Astudillo, B.Sc Thesis (2020). Topic: "Design and Construction of a Multi-purpose SCARA robot". *Co-supervisor*
- Matías Zamora, B.Sc Thesis (2019). Topic: "IoT-enabled Vermicompost System". *Main supervisor.*

Awards

RA-L Outstanding Reviewer (2025). *IEEE Robotics and Automation Society.* For distinguished reviewing service for IEEE Robotics and Automation Letters in 2024.

Excellence Award (2024). *Department of Engineering Science, University of Oxford.* In recognition of outstanding performance in 2023/2024.

Grants

PhD Exchange Fellowship (2022). *NCCR Robotics, Swiss National Science Foundation (SNSF).* £8,000 to partially support research visit at ETH Zurich.

ANID Becas Chile Scholarship (2019 – 2023). *Government of Chile.* Full scholarship (£145,000) for PhD studies at the University of Oxford.

Graduate Students Project Grant (2016). *Universidad de Chile.* £2,500 to implement a Duckietown-based course for second-year engineering students.

Professional Activities

Associate Editor

- IEEE International Conference on Robotics and Automation (ICRA) 2026
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) 2025

Reviewer

I generally serve as a reviewer for:

- IEEE Robotics and Automation Letters (RA-L)
- IEEE Transactions on Robotics (T-RO)
- IEEE Transactions on Field Robotics (T-FR)
- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)
- International Journal of Robotics Research (IJRR)

- Robotics: Science and Systems (RSS)

I have also reviewed for the Conference on Robot Learning (CoRL), British Machine Vision Conference (BMVC), IEEE/CVF International Conference on Computer Vision (ICCV), Scientific Reports, IEEE/CVF International Conference on Computer Vision and Pattern Recognition (CVPR).

Workshop Co-organisation

- *Act to Sense to Act Better: 1st Workshop on Learning and Representations for Active Perception in Manipulation*, International Conference on Robotics and Automation, Vienna, Austria (2026). *Co-organiser*
- *LocoLearn: From Bioinspired Gait Generation to Active Perception*, Conference on Robot Learning, Munich, Germany (2024). *Co-organiser*
- *Retrospective and Future of World Representations for Lifelong Robotics*, IEEE/RSJ International Conference on Intelligent Robots and Systems, Abu Dhabi, UAE (2024). *Program Committee Member*

Technical Memberships

- British Machine Vision Association (BMVA)
- Computer Vision Foundation (CVF)
- Institute of Electrical and Electronics Engineers (IEEE)

Scientific Advising

- Library of the Congress of Chile (2018–2021). Topic: Impact and State-of-development of Robotics in Chile. *Committee Member*
- Universidad de Chile (2018–2019). Topic: Innovation in Engineering Courses. *Committee Member*

Volunteering

- 7th UK Robot Manipulation Workshop, Edinburgh, UK (2026). *Demonstrator*
- IEEE/RSJ International Conference on Intelligent Robots and Systems, Madrid, Spain (2018). *Organisation support*
- International Symposium on Robotics Research 2017, Puerto Varas, Chile (2017). *Organisation support*
- Singularity Summit Chile 2016, Santiago, Chile (2016). *Robotics Mentor*
- V Congress of the Future, National Congress of Chile, Santiago, Chile (2016). *Demonstrator*
- International Conference on Computer Vision, Santiago, Chile (2015). *Organisation support*

Technical Skills

- **Languages** Spanish (Native), English (Fluent).
- **Programming** C++, Python, Arduino, ROS.
- **Development** Git, Docker.
- **Publishing** LaTeX, Inkscape, GIMP, Kdenlive.
- **Other software and technical skills** Fusion 360, 3D printing.

Matías Mattamala

Publications List

Journal Articles

(*equal contribution)

[J8] Michal Staniaszek, Tobit Flatscher, Joseph Rowell, Hanlin Niu, Wenxing Liu, Yang You, Matt Gadd, **Matías Mattamala**, Alex Schutz, Daniele De Martini, Luke Pitt, Robert Skilton, Maurice Fallon and Nick Hawes. July 2025. "AutoInspect: Towards Long-Term Autonomous Industrial Inspection". *IEEE Trans. Field Robotics*. **Invited paper**.

[J7] **Matías *Mattamala**, Jonas *Frey, Piotr Libera, Nived Chebrolu, Georg Martius, Cesar Cadena, Marco Hutter and Maurice Fallon. July 2025. "Wild Visual Navigation: Fast Traversability Learning via Pre-Trained Models and Online Self-Supervision". *Autonomous Robots*. **Invited paper**.

[J6] **Matías Mattamala**, Nived Chebrolu, Jonas Frey, Leonard Freißmuth, Haedam Oh, Benoit Casseau, Jonas Frey, Marco Hutter and Maurice Fallon. June 2025. "Building Forest Inventories with Autonomous Legged Robots — System, Lessons, and Challenges Ahead". *IEEE Trans. Field Robotics*. **Invited paper**.

[J5] Jianeng Wang, **Matías Mattamala**, Christina Kassab, Guillaume Burger, Fabio Elnecave, Lintong Zhang, Marine Petriaux and Maurice Fallon. Feb. 2025. "Exosense: A Vision-Based Scene Understanding System For Exoskeletons". *IEEE Robot. Autom. Lett. (RA-L)*.

[J4] Marco Tranzatto, [...], **Matías Mattamala** et al. Apr. 2024. "Team CERBERUS Wins the DARPA Subterranean Challenge: Technical Overview and Lessons Learned". *Field Robotics*. arXiv: 2207.04914.

[J3] Yiduo Wang, Milad Ramezani, **Matías Mattamala**, Sundara Tejaswi Digumarti and Maurice Fallon. Sept. 2022. "Strategies for Large Scale Elastic and Semantic LiDAR Reconstruction". *Robot. Auton. Syst.*

[J2] Milad Ramezani, **Matías Mattamala** and Maurice Fallon. Apr. 2022. "AEROS: AdaptivE RObust Least-Squares for Graph-Based SLAM". *Frontiers in Robotics and AI*.

[J1] **Matías Mattamala**, Nived Chebrolu and Maurice Fallon. Apr. 2022. "An Efficient Locally Reactive Controller for Safe Navigation in Visual Teach and Repeat Missions". *IEEE Robot. Autom. Lett. (RA-L)*.

Peer-Reviewed Conference Articles

[C21] Christina *Kassab, Sacha *Morin, Martin *Büchner, **Matías Mattamala**, Kumaraditya Gupta, Abhinav Valada, Liam Paull and Maurice Fallon. Dec. 2025. "OpenLex3D: A New Evaluation Benchmark for Open-Vocabulary 3D Scene Representations". *Conf. on Neural Information Processing Systems (NeurIPS)*.

[C20] Alex Schutz, Yang You, **Matías Mattamala**, Ipek Caliskanelli, Bruno Lacerda and Nick Hawes. Aug. 2025. "A Finite-State Controller Based Offline Solver for Deterministic POMDPs". *Intl. Joint Conf. on Artificial Intelligence (IJCAI)*.

[C19] Haedam Oh, Nived Chebrolu, **Matías Mattamala**, Leonard Freißmuth and Maurice Fallon. Oct. 2024. "Evaluation and Deployment of LiDAR-based Place Recognition in Dense Forests". *IEEE/RSJ Intl. Conf. Intell. Robots Syst. (IROS)*.

[C18] Benoit Casseau, Nived Chebrolu, **Matías Mattamala**, Leonard Freißmuth and Maurice Fallon. Oct. 2024. "Markerless Aerial-Terrestrial Co-Registration of Forest Point Clouds Using a Deformable Pose Graph". *IEEE/RSJ Intl. Conf. Intell. Robots Syst. (IROS)*.

[C17] Leonard Freißmuth, **Matías Mattamala**, Nived Chebrolu, Simon Schaefer, Stefan Leutenegger and Maurice Fallon. Oct. 2024. "Online Tree Reconstruction and Forest Inventory on a Mobile Robotic System". *IEEE/RSJ Intl. Conf. Intell. Robots Syst. (IROS)*.

[C16] Timo Schönegg, Turcan Tuna, Fan Yang, Gabriel Waibel, **Matías Mattamala** and Marco Hutter. July 2024. "Global Path Planning for Autonomous Vehicles in Orchards and Vineyards". *Intl. Work. on Robot Motion and Control (RoMoCo)*. **Best Conference Paper By a Young Author**.

[C15] Christina Kassab, **Matías Mattamala**, Lintong Zhang and Maurice Fallon. May 2024. "Language-EXtended Indoor SLAM (LEXIS): A Versatile System for Real-time Visual Scene Understanding". *IEEE Int. Conf. Robot. Autom. (ICRA)*.

[C14] Chong *Zhang, Jin *Jin, Jonas Frey, Nikita Rudin, **Matías Mattamala**, César Cadena and Marco Hutter. May 2024. "Resilient Legged Local Navigation: Learning to Traverse with Compromised Perception End-to-End". *IEEE Int. Conf. Robot. Autom. (ICRA)*. **Best Cognitive Robotics Paper Finalist**.

[C13] Yifu Tao, Yash Bhalgat, Lanke Frank Tarimo Fu, **Matías Mattamala**, Nived Chebrolu and Maurice Fallon. May 2024. "SiLVR: Scalable Lidar-Visual Reconstruction with Neural Radiance Fields for Robotic Inspection". *IEEE Int. Conf. Robot. Autom. (ICRA)*.

[C12] Meher V. R. Malladi, Tiziano Guadagnino, Luca Lobefaro, **Matías Mattamala**, Holger Griess, Janine Schweier, Nived Chebrolu, Maurice Fallon, Jens Behley and Cyrill Stachniss. May 2024. "Tree Instance Segmentation and Traits Estimation for Forestry Environments Exploiting LiDAR Data Collected by Mobile Robots". *IEEE Int. Conf. Robot. Autom. (ICRA)*.

[C11] Gian Erni, Jonas Frey, Takahiro Miki, **Matías Mattamala** and Marco Hutter. Oct. 2023. "MEM: Multi-Modal Elevation Mapping for Robotics and Learning". *IEEE/RSJ Intl. Conf. Intell. Robots Syst. (IROS)*.

[C10] Jonas *Frey, **Matías *Mattamala**, Nived Chebrolu, Cesar Cadena, Maurice Fallon and Marco Hutter. July 2023. "Fast Traversability Estimation for Wild Visual Navigation". *Robotics: Science and Systems (RSS)*.

[C9] Yiduo Wang, Milad Ramezani, **Matías Mattamala** and Maurice Fallon. Sept. 2021. "Scalable and Elastic LiDAR Reconstruction in Complex Environments Through Spatial Analysis". *European Conference on Mobile Robotics (ECMR)*.

[C8] **Matías Mattamala**, Milad Ramezani, Marco Camurri and Maurice Fallon. May 2021. "Learning Camera Performance Models for Active Multi-Camera Visual Teach and Repeat". *IEEE Int. Conf. Robot. Autom. (ICRA)*.

[C7] Milad Ramezani, Yiduo Wang, Marco Camurri, David Wisth, **Matías Mattamala** and Maurice Fallon. Oct. 2020. "The Newer College Dataset: Handheld LiDAR, Inertial and Vision with Ground Truth". *IEEE/RSJ Intl. Conf. Intell. Robots Syst. (IROS)*.

[C6] **Matías Mattamala**, María José Alfaro, Francisco Casado, Cristóbal Mesías, Gustavo Holmberg, Fernanda Sanchirico, Ramiro Insunza and Loreto Aguirre. 2019b. "Hackers, bandas y squads: Implementación de cursos flexibles para el desarrollo transversal de proyectos en la FCFM". *XXXII Congreso de la Sociedad Chilena de Educación en Ingeniería (SOCHEDI)*.

[C5] Cristopher *Gómez, **Matías *Mattamala**, Tim *Resink and Javier Ruiz-del-Solar. July 2018. "Visual SLAM-Based Localization and Navigation for Service Robots: The Pepper Case". *RoboCup 2018: Robot World Cup XXII*.

[C4] **Matías Mattamala**, Matías Lasen, Rodrigo Chi, Andrés Caba, Miguel Patiño, Javier Larrondo and Viviana Meruane. 2018c. "Beauchef Proyecta: Implementación Curricular de Proyectos Multidisciplinarios". *XXXI Congreso de la Sociedad Chilena de Educación en Ingeniería (SOCHEDI)*.

[C3] **Matías *Mattamala**, Gonzalo *Olave, Clayder González, Nicolás Hasbún and Javier Ruiz-del-Solar. July 2017. "The NAO Backpack: An Open-Hardware Add-on for Fast Software Development with the NAO Robot". *RoboCup 2017: Robot World Cup XXI*.

[C2] **Matías Mattamala**, Gonzalo Olave, Miguel Campusano, Cristopher Gómez, Luz Martínez, Pablo Estefó, Joakin Ugalde, Javier Urrutia, Felipe San Martín, Javier Carrasco, Pablo Villar and Rocío Gonzalez. 2017b. "Aprendizaje Interdisciplinario en Robótica: La Experiencia Innovadora de Duckietown Chile". *XXX Congreso de la Sociedad Chilena de Educación en Ingeniería (SOCHEDI)*.

[C1] **Matías Mattamala**, Constanza Villegas, José Miguel Yáñez, Pablo Cano and Javier Ruiz-del-Solar. July 2015. "A Dynamic and Efficient Active Vision System for Humanoid Soccer Robots". *RoboCup 2015: Robot World Cup XIX*.

Book Chapters

[BC3] Marco Camurri and **Matías Mattamala**. 2025g. "Leg Odometry for SLAM". *SLAM Handbook — From Localization and Mapping to Spatial Intelligence*. Ed. by Luca Carlone, Ayoung Kim, Frank Dellaert, Timothy Barfoot and Daniel Cremers. **In preparation**. Cambridge University Press.

[BC2] **Matías Mattamala**. Nov. 2020. "La promesa de los robots en los tiempos del Covid-19: Desafíos y oportunidades para Chile". *La Robótica al Servicio de la Pandemia*. Ed. by Sofía Calvo Foxley. (Spanish). Chile: Biblioteca del Congreso Nacional de Chile.

[BC1] **Matías Mattamala**. 2019a. "¿Qué es la inteligencia artificial?" *Inteligencia Artificial y Bienestar de las Juventudes en América Latina*. Ed. by Lionel Brossi, Tomás Dodds and Ezequiel Passeron. (Spanish). Chile: LOM Ediciones.

Pre-prints

[P4] Jianeng Wang, **Matías Mattamala**, Christina Kassab, Nived Chebrolu, Guillaume Burger, Fabio Elnecave, Marine Petriaux and Maurice Fallon. 2025h. "LT-Exosense: A Vision-centric Multi-session Mapping System for Lifelong Safe Navigation of Exoskeletons". arXiv: 2510.22164 [cs.RO].

[P3] Salvatore Esposito, **Matías Mattamala**, Daniel Rebain, Francis Xiatian Zhang, Kevin Dhaliwal, Mohsen Khadem and Subramanian Ramamoorthy. 2025i. "ROOM: A Physics-Based Continuum Robot Simulator for Photorealistic Medical Datasets Generation". arXiv: 2509.13177 [cs.RO].

[P2] Christina Kassab, **Matías Mattamala**, Sacha Morin, Martin Büchner, Abhinav Valada, Liam Paull and Maurice Fallon. Dec. 2024. "The Bare Necessities: Designing Simple, Effective Open-Vocabulary Scene Graphs". **Under review**. arXiv: 2412.01539 [cs.CV].

[P1] **Matías Mattamala**, Nived Chebrolu, Benoit Casseau, Leonard Freißmuth, Jonas Frey, Turcan Tuna, Marco Hutter and Maurice Fallon. May 2024. "Autonomous Forest Inventory with Legged Robots: System Design and Field Deployment". arXiv: 2404.14157.

Other Contributions

[O5] **Matías Mattamala** and Nived Chebrolu. Nov. 2023. *Tutorial on SLAM and factor graphs*. URL: https://github.com/ori-drs/slam_tutorial/ (visited on 31/10/2024).

[O4] **Matías Mattamala**. Oct. 2023. *Designing Graphics for Scientific Publications*. URL: https://github.com/mmattamala/paper-graphics (visited on 31/10/2024).

[O3] **Matías Mattamala**. Feb. 2021. *Reducing the uncertainty about the uncertainties, part 1: Linear and nonlinear*. URL: https://gtsam.org/2021/02/23/uncertainties-part1.html (visited on 16/09/2024).

[O2] **Matías Mattamala**. Feb. 2021. *Reducing the uncertainty about the uncertainties, part 2: Frames and manifolds*. URL: https://gtsam.org/2021/02/23/uncertainties-part2.html (visited on 16/09/2024).

[O1] **Matías Mattamala**. Feb. 2021. *Reducing the uncertainty about the uncertainties, part 3: Adjoints and covariances*. URL: https://gtsam.org/2021/02/23/uncertainties-part3.html (visited on 16/09/2024).