

# Frederike Dümbgen

POSTDOCTORAL RESEARCHER

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## Research Statement

My goal is to develop principled ways for robots to operate autonomously and reliably in real-world environments, basing myself on solid mathematical and theoretical foundations from the fields of optimization, signal processing, control theory, and probability theory, combined with recent advances in artificial intelligence.

## Education

### École Polytechnique Fédérale de Lausanne (EPFL)

Lausanne, Switzerland

#### PHD IN COMPUTER AND COMMUNICATION SCIENCES (EDIC)

Sep 2016 – Nov 2021

- Advisors: Prof. Martin Vetterli, Dr. Adam Scholefield, Laboratory of Audiovisual Communications (LCAV)
- Thesis title: *Blind as a Bat: Spatial Perception without Sight*
- Committee: Prof. Davide Scaramuzza, Prof. Alcherio Martinoli, Prof. Luca Carlone
- Thesis nominated for EPFL Doctorate Award

### École Polytechnique Fédérale de Lausanne (EPFL)

Lausanne, Switzerland

#### M.Sc. IN MECHANICAL ENGINEERING

Sep 2014 – Nov 2016

- Specialization in Control and Mechatronics
- Minor (20%) in Computational Science and Engineering

### Eidgenössische Technische Hochschule Zürich (ETHZ)

Zürich, Switzerland

#### MASTER'S THESIS AT AUTONOMOUS SYSTEMS LAB (PROF. ROLAND SIEGWART)

Feb 2016 – Jun 2016

- Advisors: Alireza Karimi (EPFL), Philipp Krüsi (ETHZ), Michael Blösch (ETHZ), Dominik Schindler (ETHZ)
- Thesis title: *Local Spline-Based Dense Stereo Reconstruction and Pose Estimation*

### École Polytechnique Fédérale de Lausanne (EPFL)

Lausanne, Switzerland

#### B.Sc. IN MECHANICAL ENGINEERING

Sep 2010 – Jun 2014

- Exchange year: Heriot Watt University, Edinburgh, UK

## Awards, Fellowships, Grants

|                   |   |            |
|-------------------|---|------------|
| CHF<br>105,250    | Postdoc Mobility Grant, Swiss National Science Foundation                       |            |
| 2022 EUR<br>7,000 | Women Techmaker Scholarship, Google   |            |
| 2020 2018         | Distinguished Service Award, EDIC, EPFL   |            |
| 2016              | EDIC Fellowship (given to <7% of applicants), EDIC, EPFL                        |            |
| 2016              | NCCR Robotics – Master Scholarship for Women, Swiss National Science Foundation | CHF 12,000 |
| 2015              | Finalist of NDS Competition, EPFL, Texas Instruments                            |            |
| 2011              | Admission as Fellow, Swiss Study Foundation                                     |            |

## Publications

### IN REVIEW

- F. Dümbgen, C. Holmes, B. Agro, and T. D. Barfoot, "Toward Globally Optimal State Estimation Using Automatically Tightened Semidefinite Relaxations," *arXiv:2308.05783 [cs]*, 2023, [link](#), submitted to IEEE Transactions on Robotics
- T. D. Barfoot, C. Holmes, and F. Dümbgen, "Certifiably Optimal Rotation and Pose Estimation Based on the Cayley Map," *arXiv:2308.12418 [cs]*, 2023, [link](#), submitted to International Journal of Robotics Research
- C. Holmes, F. Dümbgen, and T. D. Barfoot, "On Semidefinite Relaxations for Matrix-Weighted State-Estimation Problems in Robotics," *arXiv:2308.07275 [cs, math]*, 2023, [link](#), submitted to IEEE Transactions on Robotics
- Z. C. Guo, F. Dümbgen, J. R. Forbes, and T. D. Barfoot, "Data-Driven Batch Localization and SLAM Using Koopman Linearization," *arXiv:2309.04375 [cs]*, 2023, [link](#), submitted to IEEE Transactions on Robotics

A. Goudar, F. Dömbgen, T. D. Barfoot, and A. P. Schoellig, “Optimal Initialization Strategies for Range-Only Trajectory Estimation,” *arXiv:2309.09011 [cs]*, 2023, [link](#), submitted to IEEE Robotics and Automation Letters

#### JOURNAL PAPERS (PEER-REVIEWED)

- F. Dömbgen, C. Holmes, and T. D. Barfoot, “Safe and Smooth: Certified Continuous-Time Range-Only Localization,” *IEEE Robotics and Automation Letters*, vol. 8, no. 2, pp. 1117–1124, 2023, Presented at IROS 2023, Detroit, [link](#)
- F. Dömbgen, A. Hoffet, M. Kolundžija, A. Scholefield, and M. Vetterli, “Blind as Bat: Audible Echolocation on Small Robots,” in *IEEE Robotics and Automation Letters*, vol. 8, 2022, Presented at IROS 2022, Kyoto, [link](#)
- M. Pacholska\*, F. Dömbgen\*, and A. Scholefield, “Relax and Recover: Guaranteed Range-Only Continuous Localization,” *IEEE Robotics and Automation Letters*, vol. 5, no. 2, pp. 2248–2255, 2020, Presented at ICRA 2020 (virtual), [link](#)
- G. Baechler\*, F. Dömbgen\*, G. Elhami\*, M. Kreković\*, and M. Vetterli, “Coordinate Difference Matrices,” *SIAM Journal on Matrix Analysis and Applications*, 2020, [link](#)

#### CONFERENCE PAPERS (PEER-REVIEWED)

- Y. Chen, B. Xu, F. Dömbgen, and T. D. Barfoot, “What to Learn: Features, Image Transformations, or Both?” In *IEEE International Conference on Intelligent Robots and Systems*, 2023, [link](#)
- F. Dömbgen, M. E. Helou, and A. Scholefield, “Realizability of Planar Point Embeddings from Angle Measurements,” in *IEEE International Conference on Acoustics, Speech and Signal Processing*, 2020, [link](#)
- F. Dömbgen, C. Oeschger, M. Kolundžija, A. Scholefield, E. Girardin, J. Leuenberger, and S. Ayer, “Multi-Modal Probabilistic Indoor Localization on a Smartphone,” in *IEEE International Conference on Indoor Positioning and Indoor Navigation*, 2019, pp. 1–8, [link](#)
- F. Dömbgen, C. Schroers, and K. Mitchell, “Light Field Synthesis Using Inexpensive Surveillance Camera Systems,” in *IEEE International Conference on Image Processing*, 2019, pp. 744–748, [link](#)
- M. E. Helou, F. Dömbgen, and S. Süssstrunk, “AL2: Progressive Activation Loss for Learning General Representations in Classification Neural Networks,” in *IEEE International Conference on Acoustics, Speech and Signal Processing*, 2020, [link](#)
- M. E. Helou, F. Dömbgen, and S. Süssstrunk, “AAM: An Assessment Metric of Axial Chromatic Aberration,” in *IEEE International Conference on Image Processing*, 2018, pp. 2486–2490, [link](#)
- G. Baechler\*, F. Dömbgen\*, G. Elhami\*, M. Kreković\*, R. Scheibler, A. Scholefield, and M. Vetterli, “Combining Range and Direction for Improved Localization,” in *IEEE International Conference on Acoustics, Speech and Signal Processing*, 2018, pp. 3484–3488, [link](#)

#### CONFERENCE PAPERS (NOT PEER-REVIEWED)

- F. Dömbgen\*, M. E. Helou\*, N. Gucevskaja, and S. Süssstrunk, “Near-Infrared Fusion for Photorealistic Image Dehazing,” *IS&T/EI Proceedings*, 2018, [link](#)

#### REPORTS AND TUTORIALS (NOT PEER-REVIEWED)

- F. Dömbgen\*, M. A. Shalaby\*, C. Holmes\*, C. C. Cossette\*, J. R. Forbes, J. L. Ny, and T. D. Barfoot, “STAR-loc: Dataset for STereo And Range-based localization,” *arXiv:2309.05518 [cs.RO]*, 2023
- T. D. Barfoot, C. Holmes, and F. Dömbgen, “A Fine Line: Total Least-Squares Line Fitting as QCQP Optimization,” *arXiv:2206.05082 [cs]*, 2022, [link](#)
- M. E. Helou, F. Dömbgen, R. Achanta, and S. Süssstrunk, “Fourier-domain optimization for image processing,” *arXiv:1809.04187 [cs]*, 2018, [link](#)

#### PATENTS

- K. J. Mitchell, F. Dömbgen, and S. Liu, “Dense Reconstruction for Narrow Baseline Motion Observations,” [link](#), 2020

#### THESES

- F. Dömbgen, “Blind as a Bat: Spatial Perception without Sight,” PhD thesis, École Polytechnique Fédérale de Lausanne (EPFL), 2021, [link](#)
- F. Dömbgen, “Local spline-based dense stereo reconstruction and pose estimation,” Master’s Thesis. Eidgenössische Technische Hochschule Zürich (ETHZ), 2016

## Talks

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November 2023. *Toward plug-and-play global optimality for robotics*. Presentations at MIT, Harvard University, Northeastern University and Tufts University. [Video](#) and [slides](#) available online.

August 2023. *Toward Globally Optimal Solvers for Robotics and Beyond*. Invited talk at *Signal Processing and Friends* conference, EPFL. Also presented at LASA (Prof. Aude Billard), EPFL. [Description](#) and [slides](#) available online.

March 2023. *Towards Globally Optimal State Estimation*. Invited talk at *Toronto AIR Seminar*, University of Toronto. [Description](#) and [video](#) available online.

May 2021. *From Autonomous Lawn Mowers to Bat Drones: Dynamical Distance Geometry in the Wild*. Invited talk at *Mini-symposium on Sensor Network Localization and Dynamical Distance Geometry*, Fields Institute, Toronto (online). [Description](#) and [video](#) available online.

January 2020. *Guaranteed Distance-based Trajectory Estimation*. Talk during lab visit of RPG (Prof. Davide Scaramuzza), University of Zürich. [Slides](#) available online.

June 2019. *Towards Multimodal Indoor Localization*. Invited talk at *DIMACS Workshop on Distance Geometry: Theory and Applications* at Rutgers University. [Description](#) and [video](#) available online.

## Professional Experience – Academia

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Apr 2022 – Present **Postdoctoral Researcher**, Robotics Institute, University of Toronto

Conducted own research, collaborated with 3 PhD, 1 Master and 1 Bachelor students, supervised summer research project. Contributed to and organized community-building events.

Nov 2021 – Feb 2022 **Research Assistant**, LCAV, EPFL

Finalized publication of work from PhD thesis and co-supervised students.

Sep 2011 – Sep 2021 **Teaching Assistant**, EPFL

Supported exercise sessions and grading for numerous Bachelor and Master-level courses (see *Teaching Experience* for a full list).

Jun 2015 – Aug 2015 **Summer Research Assistant**, LCAV, EPFL

Set up and programmed webcams for visual robot tracking and created robot operation pipeline in python for collecting odometric, visual and acoustic data in *Python*.

## Professional Experience – Industry

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Feb 2018 – Nov 2018 **Lab Associate**, Disney Research Los Angeles, California, United States

Implemented learning-based view synthesis algorithm for motion capture using a linear camera array. Successfully published and presented the accomplished work at conference ICIP 2019.

Apr 2014 – Sep 2014 **Product Management Intern**, Bystronic Laser AG, Berne, Switzerland

Designed and implemented global sales tool calculating and visualizing the total cost of ownership of laser and waterjet cutting machines. Organized the launching of the tool in global sales offices.

Sep 2013 – Mar 2014 **Technical Training Intern**, ABB High Voltage Products, Zürich, Switzerland

Designed online e-Learning courses for supplier admission and high voltage factory safety and conducted hands-on training sessions for mechanical assembly of gas-insulated switch gear systems.

Jul 2013 – Aug 2013 **Workshop Training Intern**, Reinhard AG, Huttwil, Switzerland

Acquired mechanical skills including operating CNC and drilling machines and a lathe.

## Teaching Experience

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### INSTRUCTOR

**Mathematics for Robotics (ROB310)**, Instructor of 3rd year Engineering Science class

- Probability and Statistics (Bayesian statistics, MAP estimation, Kalman filter)
- 2022 • Numerical Methods (numerical integration and differentiation, conditioning)
- Optimization (root finding, convex and non-convex optimization)

UofT

## TEACHING ASSISTANT

|      |   |      |
|------|---|------|
| 2020 | <b>Signal Processing for Communications</b> , Teaching Assistant                      | EPFL |
| 2019 | <b>Mathematical Foundations of Signal Processing</b> , Teaching Assistant for FRI lab | EPFL |
| 2016 | <b>Physics I</b> , Teaching Assistant   | EPFL |
| 2015 | <b>Robotics Competition</b> , Created catalogue and onboarding documents              | EPFL |
| 2015 | <b>Probability and Statistics</b> , Teaching Assistant                                | EPFL |
| 2014 | <b>Linear Algebra I</b> , Teaching Assistant  | EPFL |

## PROJECT SUPERVISOR

|      |  |      |
|------|--|------|
| 2023 | <b>Demo for Certifiably Optimal Drone Localization</b> , Summer research project                     | UofT |
| 2021 | <b>Droning drones: melodies on the fly</b> , Master's semester project                               | EPFL |
| 2021 | <b>Audio-based algorithms for the e-puck robot</b> , Master's semester project                       | EPFL |
| 2020 | <b>Simulation framework for audible echolocation</b> , Summer research project (remote)              | EPFL |
| 2020 | <b>Learning acoustics-based localization of a blind drone</b> , Master's semester project/internship | EPFL |
| 2019 | <b>Learning-based approaches for indoor localization</b> , Master's semester projects/internships    | EPFL |
| 2019 | <b>Modular mobile robot for localization experiments</b> , Master's semester project                 | EPFL |
| 2019 | <b>Bring voice user-interfaces to our offices</b> , Master's semester project                        | EPFL |
| 2018 | <b>Python package for localization with angular measurements</b> , Master's semester project         | EPFL |

## OTHER TEACHING EXPERIENCE

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|-----------|--|-------------|
| 2023      | <b>Presentation on Python best practices</b> , Student-run tutorial series at RI           | UofT        |
| 2017–2019 | <b>Head of app development team, teaching volunteers</b> , voCHabular (non-for-profit)     | Switzerland |
| 2017      | <b>Organizer of Python workshop for young professionals</b> , Powercoders (non-for-profit) | Switzerland |

## Outreach & Community Service

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### MEDIA COVERAGE

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|----------|--|
| Feb 2023 | <b>Media Coverage</b> , Research on bat-like drones covered in multiple news outlets: <a href="#">New Scientist</a> , <a href="#">TechXplore</a> , <a href="#">netzwoche</a> , <a href="#">popsci</a> and <a href="#">engadget</a> . |
| Jan 2023 | <b>Invited blog post</b> , <a href="#">Post</a> about bat-like drones for <i>bitcraze</i> (creator of <i>Crazyflie</i> drone).   |

### SERVICE

|           |   |
|-----------|---|
| 2023      | <b>Session Chair at IEEE IROS conference</b> , Detroit, U.S.  |
| 2023      | <b>Presentation at outreach event of RI for high school students</b> , UofT   |
| 2021      | <b>Interview with science outreach department</b> . Video available <a href="#">online.</a> , EPFL                  |
| 2019      | <b>Co-organizer of Eurotech summer school <i>Open Science in Practice</i></b> , EPFL                                |
| 2019      | <b>Presentation of LCAV for visiting Swiss-German high school students (2 events)</b> , EPFL                        |
| 2017–2018 | <b>Workshop tutor and spokesperson, for GirlsCoding (non-for-profit)</b> , Switzerland                              |
| 2018      | <b>Co-organizer of EPFL &amp; ETHZ summer school <i>Reproducibility in Computational Sciences</i></b> , Switzerland |
| 2016–2018 | <b>Elected PhD student representative for EDIC committee</b> , EPFL   |
| 2016–2017 | <b>Organizer of lunch talks of EDIC PhD student association</b> , EPFL  |

### PEER REVIEW

IEEE Transactions on Robotics

IEEE Transactions on Mobile Computing

IEEE Robotics and Automation Letters

IEEE Signal Processing Letters

IEEE/RSJ International Conference on Intelligent Robots and Systems

Discrete Applied Mathematics (Elsevier)

## Other

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### TECHNICAL STRENGTHS

Programming: Python (proficient), C++, C, Matlab (comfortable), Ruby, Javascript, Java (basics)

Computer Aided Design: Catia, Solidworks, Onshape

Other: Robot Operating Systems, git, LaTeX, Unix OS

### LANGUAGE SKILLS

German (native)

English and French (B2, fluent)

Italian (A2/B1, conversational)

### CITIZENSHIP

Swiss and German citizen

### PROFESSIONAL MEMBERSHIPS

IEEE Member

IEEE Robotics and Automation Society (RAS) Member