# 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

2022 **Postdoc Mobility Grant**, Swiss National Science Foundation
2020 **Women Techmaker Scholarship**, Google
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
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. Dümbgen, 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. Dümbgen, 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. Dümbgen, 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. Dümbgen*, 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. Dümbgen*, G. Elhami*, M. Kreković*, and M. Vetterli, "Coordinate Difference Matrices," *SIAM Journal on Matrix Analaysis and Applications*, 2020, link

## Conference Papers (peer-reviewed)

Y. Chen, B. Xu, F. Dümbgen, and T. D. Barfoot, "What to Learn: Features, Image Transformations, or Both?" In *IEEE International Conference on Intelligent Robots and Systems*, 2023, link

F. Dümbgen, 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. Dümbgen, 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. Dümbgen, 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. Dümbgen, and S. Süsstrunk, "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. Dümbgen, and S. Süsstrunk, "AAM: An Assessment Metric of Axial Chromatic Aberration," in *IEEE International Conference on Image Processing*, 2018, pp. 2486–2490, link

G. Baechler*, F. Dümbgen*, 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. Dümbgen*, M. E. Helou*, N. Gucevska, and S. Süsstrunk, "Near-Infrared Fusion for Photorealistic Image Dehazing," *IS&T EI Proceedings*, 2018, link

## Reports and Tutorials (not peer-reviewed)

F. Dümbgen*, 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. Dümbgen, "A Fine Line: Total Least-Squares Line Fitting as QCQP Optimization," *arXiv:2206.05082 [cs]*, 2022, link

M. E. Helou, F. Dümbgen, R. Achanta, and S. Süsstrunk, "Fourier-domain optimization for image processing," *arXiv:1809.04187 [cs]*, 2018, link

## Patents

K. J. Mitchell, F. Dümbgen, and S. Liu, "Dense Reconstruction for Narrow Baseline Motion Observations," link, 2020

## Theses

F. Dümbgen, "Blind as a Bat: Spatial Perception without Sight," PhD thesis, École Polytechnique Fédérale de Lausanne (EPFL), 2021, link

F. Dümbgen, "Local spline-based dense stereo reconstruction and pose estimation," Master's Thesis. Eidgenössische Technische Hochschule Zürich (ETHZ), 2016

## Talks

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 *Minisymposium 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 Rutger's University. Description and video available online.

## Professional Experience – Academia

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|---|---|
| Apr 2022 – Present | **Postdoctoral Researcher**, Robotics Institute, University of Toronto<br>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<br>Finalized publication of work from PhD thesis and co-supervised students. |
| Sep 2011 – Sep 2021 | **Teaching Assistant**, EPFL<br>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<br>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<br>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<br>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<br>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<br>Acquired mechanical skills including operating CNC and drilling machines and a lathe. |

## Teaching Experience

### Instructor

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

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

2022 *UofT*

### Teaching Assistant

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

### Project Supervisor

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

### Other Teaching Experience

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

## Outreach & Community Service

### Media Coverage

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| Feb 2023 | **Media Coverage**, Research on bat-like drones covered in multiple news outlets: New Scientist, TechXplore, netzwoche, popsci and engadget. |
| Jan 2023 | **Invited blog post**, Post about bat-like drones for *bitcraze* (creator of *Crazyflie* drone). |

### Service

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

### 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