# Kevin J. Doherty

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## Research interests

My research interests are at the intersection of autonomous robot navigation and machine learning. I am interested in the algorithms and representations needed to give real robots the ability to operate robustly for extended periods of time without human intervention.

## Education

**2017 - 2023** **Ph.D Aeronautics & Astronautics and Ocean Engineering**,
*Massachusetts Institute of Technology & Woods Hole Oceanographic Institution*.
Thesis: *Lifelong, Learning-Augmented Robot Navigation*
Advisor: John J. Leonard
Committee: Luca Carlone, Erin Fischell, Nicholas Roy, Michael Kaess
MIT/WHOI Joint Program

**2019** **S.M. Aeronautics & Astronautics and Ocean Engineering**,
*Massachusetts Institute of Technology & Woods Hole Oceanographic Institution*.
Thesis: *Robust Non-Gaussian Semantic SLAM*
Advisor: John J. Leonard
MIT/WHOI Joint Program

**2017** **B.E. Electrical Engineering**, *Stevens Institute of Technology*.
Thesis: *Learning-aided 3D Occupancy Mapping for Mobile Robots*
Advisor: Brendan J. Englot
Minor: Computer Science

## Honors and awards

**2022** **RSS Pioneers**, Robotics: Science and Systems 2022

**2020** **Ruth and Paul Fye Award for Excellence in Oceanographic Research**: Best Graduate Student Paper between 2015-2020 in Applied Ocean Science and Engineering, MIT/WHOI Joint Program

**2018** **Best Paper Award Finalist**, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS) (6 finalists of 1,254 accepted papers)

**2018** **NSF Graduate Research Fellowship Award**

**2018** MIT Graduate Student Council Travel Grant

**2018** Link Ocean Engineering Fellowship Honorable Mention

**2017** Batchelor Award, in recognition of the highest graduating GPA in electrical engineering at Stevens Institute of Technology

**2017** IEEE Robotics and Automation Society ICRA Travel Grant

**2015** ICFNJ Research Symposium Grant, in support of undergraduate research on underwater robotics

**2013** Anne P. Neupauer Scholarship, a four year, full-tuition merit scholarship granted by Stevens Institute of Technology

## ▬▬▬ Experience

**2023 - Present**  **Research engineer**, *Boston Dynamics*.
My research work at Boston Dynamics is focused on perception and state estimation for the Atlas humanoid robot, with application to complex bimanual manipulation tasks. My primary focus has been on *object* state estimation, which was a key enabling technology for several recent demonstrations in videos like *Atlas Goes Hands On*, as well as earlier work on HD Atlas like *Atlas Struts*. Beyond that, I have also been involved with the development of new *robot* state estimation technologies, both directly on the Atlas team and in support of the Stretch team.

**2017 - 2023**  **Doctoral candidate**, *Computer Science and Artificial Intelligence Lab*, MIT.
My doctoral research work involves the development of robust and resource-efficient algorithms and representations necessary to achieve lifelong, learning-augmented robot navigation, including: new tools and inference algorithms for integrating learning-based perception methods, like object detectors, with traditional SLAM; computationally efficient graph sparsification methods for long-term SLAM.

**2015 - 2017**  **Undergraduate research assistant**, *Robust Field Autonomy Lab*, Stevens Inst. of Technology.
My undergraduate research focused on efficient robot exploration and mapping using sparse, noisy sensor data. Developed learning-based techniques to aid fast exploration of *a priori* unknown environments, as well as real-time mapping approaches leveraging machine learning techniques.

**2016**  **Research intern**, *MIT Lincoln Laboratory*.
Developed algorithms for semantic map filtering and object localization to enhance situational awareness via a heads-up display, with application to search using lightweight UAVs and UUVs.

**2014 - 2016**  **Software engineering intern**, *Cizr Tennis*.
Front- and back-end development for a tennis video annotation and editing platform. Built several production features for uploading matches, saving match events, and producing highlight reels.

**2014 - 2016**  **Software engineering intern**, *Resolute Innovation*.
Prototyped web crawlers and parsers for a university tech-transfer search engine. Built user account and saved document support. Researched techniques for machine learning-assisted expert data curation.

## ▬▬▬ Publications

### Book chapters

[B1] Arash Asgharivaskasi, **Kevin Doherty**, Jens Behley, Nathan Hughes, Yun Chang, John Leonard, Henrik I. Christensen, Luca Carlone, and Nikolay Atanasov. *Metric-Semantic SLAM*. Cambridge University Press.

### Journal publications

[J1] **Kevin J Doherty**, Ziqi Lu, Kurran Singh, and John J Leonard. Discrete-Continuous Smoothing and Mapping. *IEEE Robotics and Automation Letters*, 2022.

[J2] Erik Pearson, **Kevin Doherty**, and Brendan Englot. Improving obstacle boundary representations in predictive occupancy mapping. *J. of Robotics and Autonomous Systems*, 2022.

[J3] David M Rosen, **Kevin J Doherty**, Antonio Terán Espinoza, and John J Leonard. Advances in Inference and Representation for Simultaneous Localization and Mapping. *Annual Review of Control, Robotics, and Autonomous Systems*, 4, 2021. Invited article.

[J4] **Kevin Doherty**, Tixiao Shan, Jinkun Wang, and Brendan Englot. Learning-aided 3-D Occupancy Mapping with Bayesian Generalized Kernel Inference. *IEEE Trans. Robotics*, 35(4), 2019.

### Refereed conference proceedings

[C1] Alan Papalia, Joseph Morales, **Kevin J Doherty**, David M Rosen, and John J Leonard. SCORE: A Second-Order Conic Initialization for Range-Aided SLAM. In *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2023.

[C2] **Kevin J Doherty**, David M Rosen, and John J Leonard. Spectral Measurement Sparsification for Pose-Graph SLAM. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2022.

[C3]  Ziqi Lu, Yihao Zhang, **Kevin Doherty**, Odin Severinsen, Ethan Yang, and John J. Leonard. SLAM-Supported Self-Training for 6D Object Pose Estimation. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2022.

[C4]  **Kevin J Doherty**, David M Rosen, and John J Leonard. Performance Guarantees for Spectral Initialization in Rotation averaging and Pose-Graph SLAM. In *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2022.

[C5]  Ziqi Lu, Qiangqiang Huang, **Kevin Doherty**, and John J. Leonard. Consensus-Informed Optimization Over Mixtures for Ambiguity-Aware Object SLAM. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2021.

[C6]  Jiahui Fu, Qiangqiang Huang, **Kevin Doherty**, Yue Wang, and John J. Leonard. A Multi-Hypothesis Approach to Pose Ambiguity in Object-Based SLAM. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2021.

[C7]  John D Martin*, **Kevin Doherty***, Caralyn Cyr, Brendan Englot, and John Leonard. Variational Filtering with Copula Models for SLAM. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2020. *Equal contributors.

[C8]  **Kevin J Doherty**, David P Baxter*, Edward Schneeweiss*, and John J Leonard. Probabilistic Data Association via Mixture Models for Robust Semantic SLAM. In *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2020. *Equal contributors.

[C9]  **Kevin Doherty**, Dehann Fourie, and John Leonard. Multimodal Semantic SLAM with Probabilistic Data Association. In *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2019.

[C10] **Kevin Doherty**, Genevieve Flaspohler, Nicholas Roy, and Yogesh Girdhar. Approximate Distributed Spatiotemporal Topic Models for Multi-Robot Terrain Characterization. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2018. Best Paper Award Finalist (6 finalists of 1,254 papers).

[C11] Tixiao Shan, **Kevin Doherty**, Jinkun Wang, and Brendan Englot. Bayesian Generalized Kernel Inference for Terrain Traversability Mapping. In *Conference on Robot Learning*, 2018.

[C12] **Kevin Doherty**, Jinkun Wang, and Brendan Englot. Bayesian Generalized Kernel Inference for Occupancy Map Prediction. In *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2017.

[C13] **Kevin Doherty**, Jinkun Wang, and Brendan Englot. Probabilistic Map Fusion for Fast, Incremental Occupancy Mapping with 3D Hilbert Maps. In *IEEE Intl. Conf. on Robotics and Automation (ICRA)*, 2016.

[C14] Shi Bai, Jinkun Wang, **Kevin Doherty**, and Brendan Englot. Inference-enabled Information-theoretic Exploration of Continuous Action Spaces. In *Proc. of the Intl. Symp. of Robotics Research (ISRR)*, 2015.

## Workshop and other publications

[M1]  Jan Czarnowski, **Kevin Doherty**, Tristan Laidlow, Shreyas Shivakumar, Eric Storm, Sudharshan Suresh, and Alberto Rodriguez. Making Atlas See the World. Blog post. https://bostondynamics.com/blog/making-atlas-see-the-world/, May 2025.

[M2]  **Kevin J Doherty**, Ziqi Lu, Kurran Singh, and John J Leonard. Discrete-Continuous Smoothing and Mapping. *ICRA Workshop on Robot Perception and Mapping: Emerging Techniques*, 2022. Spotlight talk (2 selected out of 48 submissions).

[M3]  **Kevin Doherty** and Yogesh Girdhar. Unsupervised Spatial-Semantic Maps for Human-Robot Collaboration in Communication-Constrained Environments. In *IEEE/RSJ Intl. Conf. on Intelligent Robots and Systems (IROS)*, 2017. Poster.

## Open-source software

- **DC-SAM:** The discrete-continuous smoothing and mapping (DC-SAM) library provides a unified set of interfaces and solvers for discrete-continuous robot perception problems, developed at the Marine Robotics Group at MIT.
  github.com/MarineRoboticsGroup/dcsam

- **MAC:** MAC is an algorithm for graph sparsification that aims to preserve the algebraic connectivity of graphs, developed at the Marine Robotics Group at MIT.
  github.com/MarineRoboticsGroup/mac

- **LA3DM:** The Learning-aided 3D Mapping Library (LA3DM) provides implementations of recent learning-based mapping approaches developed at the Robust Field Autonomy Lab at Stevens Institute of Technology.
  github.com/RobustFieldAutonomyLab/la3dm

## Teaching

**2021 Lesson Planning Certificate (recipient)**, *MIT*.
Three-part lesson planning workshop focused on: preparing lesson plans for courses or recitations, developing presentation skills and effective classroom activities, giving formative feedback.

**2020 Instructor, Linear Algebra**, *MIT-WHOI Joint Program Math Review*.
Developed course material for a review of linear algebra tailored toward incoming MIT graduate students. Taught key linear algebra concepts, and held office hours. Content included linear spaces and linear transformations, bases, independence, eigenvalues and singular values

**2020 Subject Design Certificate (recipient)**, *MIT*.
Three-part workshop dealing with the fundamentals of course design, including: defining learning outcomes, selecting appropriate assessments, creating an inclusive classroom, and syllabus design.

**2019 Teaching assistant, 16.485 Visual Navigation**, *MIT*.
Worked with instructors Luca Carlone and Kasra Khosoussi to familiarize students with the mathematical foundations of visual navigation and state-of-the-art algorithms, which students implement and test using the Intel Aero drone platform. Developed assignment materials and weekly lab sessions.

**2017 Course staff, 6.S198 Deep Learning Practicum**, *MIT*.
Developed course content using deeplearn.js relating to generative adversarial networks and other deep generative models.

## Selected talks and seminars

**2024 Picking up momentum (Boston Dynamics)**, *Stevens Institute of Technology*, November 2024.
Stevens Institute for Artificial Intelligence (SIAI) Seminar. Host: Brendan Englot.

**2024 KFC Fusion: Cooking up kinematics, forces, and camera data for object state estimation (Boston Dynamics)**, *Robotics: Science and Systems*, July 2024.
Dexterous Manipulation Workshop `view on youtube`

**2024 Picking up momentum (Boston Dynamics)**, *TU Munich*, January 2024.
Guest Lecture. Autonomous Systems. Host: Markus Ryll.

**2023 Factor graph representations for hybrid perception problems**, *University of Michigan*, April 2023.
Guest Lecture. Mobile Robotics: Methods & Algorithms. Host: Maani Ghaffari. `view on youtube`

**2022 Lifelong, Learning-Augmented Robot Navigation**, *Mitsubishi Electric Research Laboratories (MERL)*, January 2023.

**2022 Lifelong, Learning-Augmented Robot Navigation**, *Woods Hole Oceanographic Institution (WHOI) AOPE Seminar*, December 2022.

**2022 Discrete-Continuous Smoothing and Mapping**, *Northeastern Robotics Colloquium (NERC)*, October 2022.

**2022 Discrete-Continuous Smoothing and Mapping: Progress and Opportunities**, *Robust Autonomy Lab, Northeastern University*, August 2022.

| 2022 | **Performance Guarantees for Spectral Initialization in Rotation Averaging and Pose-Graph SLAM**, *LIDS Student Conference, MIT*, January 27, 2022. |
| 2021 | **Robust Semantic SLAM: Representation and Inference**, *Tartan SLAM Series, Carnegie Mellon University*, August, 2021. `view on youtube` |
| 2021 | **Robust Semantic SLAM: Mixture Representations and Discrete-Continuous Optimization**, *Robot Perception Lab, Carnegie Mellon University* , August, 2021. |
| 2020 | **Robust Semantic SLAM**, *Naval Undersea Warfare Center (NUWC)*, October, 2020. |
| 2020 | **The Role of SLAM in Embodied Intelligence**, *Learning and Intelligent Systems Group, MIT*, July, 2020. |
| 2019 | **Robust Non-Gaussian Semantic SLAM**, *Boston University*, November, 2019. ONR-MURI: Neuroscience-Inspired Perception, Navigation, and Spatial Awareness for Autonomous Robots. `press release` |
| 2019 | **Autonomous Underwater Vehicle Navigation**, *MIT Lincoln Laboratory*, November 2019. Guest Lecture. Undersea Systems and Technology Internal Technical Education Course. Host: Jordan Rosenthal. |

# Mentorship and outreach

## Mentorship

| 2017 - present | **Undergraduate student research mentor**. Mentored multiple undergraduate students on research projects: <br>○ **Zoe Wong** (MIT) <br>○ **Ishita Goluguri** (MIT) <br>○ **Lilly Papalia** (MIT Undergraduate Thesis in Mechanical Engineering) |
| 2018 - present | **Graduate student research mentor**. Mentored multiple graduate students on research projects: <br>○ **Ziqi Lu** (MIT) <br>○ **Kurran Singh** (MIT) <br>○ **Alan Papalia** (MIT) <br>○ **Violet Killy** (MIT) <br>○ **David Baxter** (MIT) <br>○ **Edward Schneeweiss** (UMass Amherst) |

## Outreach and other activities

| 2020-2022 | **MIT-WHOI Joint Program ASK Mentor**. The Joint Program Applicant Support and Knowledge-base (JP ASK) provides advice and support to potential MIT-WHOI program applicants who are underrepresented or unfamiliar with MIT, WHOI, or ocean sciences. Met with prospective students, provided feedback and advice on fellowships and research statements, and generally provided support throughout the application process. |
| 2021 | **MIT AeroAstro Graduate Application Assistance Program (GAAP)**. The AeroAstro GAAP program provides mentorship to students from underrepresented backgrounds applying to MIT. Met with prospective students, provided feedback on research statements, and generally advised and supported students throughout the application process. |
| 2021 | **MIT AeroAstro Ambassador**. Student representative during MIT AeroAstro's 2021 Open House for admitted students. Corresponded with admitted students to and participated in Open House activities. |
| 2020 - 2021 | **MIT-WHOI Joint Program Representative**. MIT student organization dedicated to supporting the needs of Joint Program students. Specific responsibilities include coordinating with administrators and organizing the annual accepted students' open house and social events. |
| 2019-2020 | **MIT-WHOI Joint Program Engineering Student Visit Day**. Organized tours and student meetings for MIT-WHOI Joint Program Applied Ocean Science and Engineering department accepted students. |

2019 **Open Ocean Initiative**, *MIT.*
Presented and demonstrated marine robot navigation and communication (with Brendan O'Neill) for roughly 100 international middle school students visiting MIT.
**Other activities:**
○ Tau Beta Pi (TBP) Honor Society
○ Eta Kappa Nu (HKN) Honor Society

# Professional service

## Associate editor
2023 **IROS:** IEEE/RSJ International Conference on Intelligent Robots and Systems

## Organizer
2023 **Robotic Perception and Mapping: Frontiers in Learning and Vision (IROS 2023):** Co-organizer of the IROS 2023 workshop on robotic perception and mapping (ROPEM).
ROPEM 2023 Website

2023 **Spectral Graph-Theoretic Methods for Estimation and Control (RSS 2023):** Organizer of the RSS 2023 workshop on Spectral Graph-Theoretic Methods for Estimation and Control (SGTM).
SGTM 2023 Website

2023 **RSS Pioneers:** Organizer and program committee member for RSS Pioneers 2023.
RSS Pioneers 2023 Website

## Program committees
2023 **RSS Pioneers:** Robotics: Science and Systems Pioneers
2020 **CoRL:** Conference on Robot Learning

## Journal reviewer
2017 - 2023 **RA-L:** IEEE Robotics and Automation Letters
2019 - 2023 **T-RO:** IEEE Transactions on Robotics
2020 **AURO:** Autonomous Robots
2019 **IJRR:** International Journal of Robotics Research

## Conference reviewer
2023 **RSS:** Robotics: Science and Systems
2017 - 2022 **ICRA:** IEEE International Conference on Robotics and Automation
2018-2022 **IROS:** IEEE/RSJ International Conference on Intelligent Robots and Systems

## Volunteer
2020 **CoRL:** Conference on Robot Learning
2017 **RSS:** Robotics: Science and Systems

# References

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**David M. Rosen**
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