Kevin J. Doherty

PhD Student

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Research interests

My research interests lie at the intersection of **autonomous robot navigation** and **machine learning**. I am interested in the **algorithms and representations** needed to endow real robots with the capabilities to operate robustly over long time horizons without human intervention, supported by active, lifelong learning.

Education

2017 - present **Ph.D Aeronautics & Astronautics and Ocean Engineering**,
Massachusetts Institute of Technology & Woods Hole Oceanographic Institution.
Advisor: John J. Leonard
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

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

Research

2017 - present **Doctoral student**, *Computer Science and Artificial Intelligence Lab*, MIT.
Researcher in the Marine Robotics Group advised by John Leonard. My current work involves developing methods to quantify and mitigate uncertainty in robot perception, with application to semantic navigation.

2015 - 2017 **Undergraduate research assistant**, *Robust Field Autonomy Lab*, Stevens Institute of Technology.
Studied autonomous robotics with specific interest in the problems of mapping and exploration. Investigated techniques to aid fast exploration of unknown environments. Developed approximate mapping approaches based on fusion of independent classifiers. Developed mapping approach using Bayesian kernel inference for real-time mapping using sparse range data.

2016 **Research intern**, *MIT Lincoln Laboratory*.
Developed algorithms for semantic map filtering and object localization with application to search using lightweight UAVs and UUVs. Integrated algorithms into a SLAM system with the goal of enhancing situational awareness for a user via a heads-up display.

Industry

2014 - 2016 **Software engineering intern**, *Cizr Tennis*.
Back- and front-end development for a tennis video annotation and editing platform. Built several features currently in production for uploading matches, saving match events, and generating and sharing highlight reels. `www.cizrtennis.com`

2014 - 2016 **Software engineering intern**, *Resolute Innovation*.
Prototyped web crawlers and parsers for the backend of a university tech-transfer search engine. Built support for user accounts and saved documents. Studied techniques for machine learning-assisted expert data curation. `www.resolute.ai`

Teaching

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

2020 **Subject Design Certificate (recipient)**, *MIT*.
Completed a three-part course design workshop dealing with the fundamentals of college-level course design. These include: defining learning outcomes, selecting appropriate assessments, creating an inclusive classroom, and syllabus design. `Workshop information here.`

2019 **Teaching assistant, 16.485 Visual Navigation**, *MIT*.
This course, taught by Prof. Luca Carlone and Dr. Kasra Khosoussi, is concerned with the theory and practice of navigation using visual and inertial sensors for a variety of autonomous systems. We aim 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. Primary responsibilities include developing 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.

Publications

Journal publications

[J1] 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.

[J2] **Kevin Doherty**, Tixiao Shan, Jinkun Wang, and Brendan Englot. Learning-aided 3-D Occupancy Mapping with Bayesian Generalized Kernel Inference. *IEEE Transactions on Robotics*, 35(4):953–966, 2019.

Refereed conference proceedings

[C1] John D Martin*, **Kevin Doherty***, Caralyn Cyr, Brendan Englot, and John Leonard. Variational Filtering with Copula Models for SLAM. In *arXiv preprint arXiv:2008.00504*, 2020. *Equal contributors.

[C2] **Kevin J Doherty**, David P Baxter*, Edward Schneeweiss*, and John J Leonard. Probabilistic Data Association via Mixture Models for Robust Semantic SLAM. In *2020 IEEE International Conference on Robotics and Automation (ICRA)*, pages 1098–1104. IEEE, 2020. *Equal contributors.

[C3] **Kevin Doherty**, Dehann Fourie, and John Leonard. Multimodal Semantic SLAM with Probabilistic Data Association. In *2019 international conference on robotics and automation (ICRA)*, pages 2419–2425. IEEE, 2019.

[C4] **Kevin Doherty**, Genevieve Flaspohler, Nicholas Roy, and Yogesh Girdhar. Approximate Distributed Spatiotemporal Topic Models for Multi-Robot Terrain Characterization. In *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 3730–3737. IEEE, 2018. **Best Paper Award Finalist (6 finalists of 1,254 papers**.

[C5] Tixiao Shan, Jinkun Wang, Brendan Englot, and **Kevin Doherty**. Bayesian Generalized Kernel Inference for Terrain Traversability Mapping. In *Conference on Robot Learning*, pages 829–838. PMLR, 2018.

[C6] **Kevin Doherty**, Jinkun Wang, and Brendan Englot. Bayesian Generalized Kernel Inference for Occupancy Map Prediction. In *2017 IEEE International Conference on Robotics and Automation (ICRA)*, pages 3118–3124. IEEE, 2017.

[C7] **Kevin Doherty**, Jinkun Wang, and Brendan Englot. Probabilistic Map Fusion for Fast, Incremental Occupancy Mapping with 3D Hilbert Maps. In *2016 IEEE International Conference on Robotics and Automation (ICRA)*, pages 1011–1018. IEEE, 2016.

[C8] Shi Bai, Jinkun Wang, **Kevin Doherty**, and Brendan Englot. Inference-enabled Information-theoretic Exploration of Continuous Action Spaces. In *International Symposium on Robotics Research (ISRR*, pages 419–433. Springer, 2015.

Other publications

[Misc1] **Kevin Doherty**, Dehann Fourie, and John Leonard. Robust Semantic Navigation with Probabilistic Data Association. In *MIT College of Computing Launch*, 2019.

[Misc2] **Kevin Doherty** and Yogesh Girdhar. Unsupervised Spatial-Semantic Maps for Human-Robot Collaboration in Communication-Constrained Environments. In *IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS*, 2017.

[Misc3] **Kevin Doherty**, Jinkun Wang, and Brendan Englot. Bayesian Learning with Generalized Kernels for Occupancy Map Prediction. In *IEEE MIT Undergraduate Research Technology Conference*.

Selected talks and lectures

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.

2020 **Robust Semantic SLAM**, *ICRAxMIT*, June, 2020.

2019 **Autonomous Underwater Vehicle Navigation**, *MIT Lincoln Laboratory*, November, 2019.
Undersea Systems and Technology Internal Technical Education Course. Host: Jordan Rosenthal.

2019 **Robust Non-Gaussian Semantic SLAM**, *Boston University*, November, 2019.
ONR-MURI: Neuroscience-Inspired Perception, Navigation, and Spatial Awareness for Autonomous Robots. Press release.

Open-source software

- **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 with Jinkun Wang.
  `https://github.com/RobustFieldAutonomyLab/la3dm`

Professional service

Program committees

2020 **CoRL:** Conference on Robot Learning

Journal reviewer

2020 **AURO:** Autonomous Robots

2017 - 2021 **RA-L:** IEEE Robotics and Automation Letters

2019 **T-RO:** IEEE Transactions on Robotics

2019 **IJRR:** International Journal of Robotics Research

Conference reviewer

2017 - 2021 **ICRA:** IEEE International Conference on Robotics and Automation

2018-2020 **IROS:** IEEE/RSJ International Conference on Intelligent Robots and Systems

Volunteer

2020 **CoRL:** Conference on Robot Learning

2017 **RSS:** Robotics: Science and Systems

Outreach and other 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 throughout the year.

2020 **MIT-WHOI Joint Program ASK Mentor**.
The Joint Program Applicant Support and Knowledge-base (JP ASK) is a program providing advice and support to potential graduate students who are underrepresented or unfamiliar with MIT, WHOI, or ocean sciences, including, but not limited to: first-generation graduate applicants, members of underrepresented groups in ocean sciences and engineering, non-traditional students returning to school after a career change, or applicants with financial hardship.

2019-2020 **MIT-WHOI Joint Program Engineering Student Visit Day**.
Coordinated faculty and student meetings, as well as tours for accepted students to the MIT-WHOI Joint Program Applied Ocean Science Engineering department.

2019 **Open Ocean Initiative**, *MIT*.
Presentation and demonstration of "Marine Robot Navigation and Communication" (with Brendan O'Neill) for ≈ 100 international middle school students visiting MIT.

Other activities:

- IEEE Robotics and Automation Society (RAS)
- Tau Beta Pi (TBP) Honor Society
- Eta Kappa Nu (HKN) Honor Society
- MIT CSAIL Buddy (2018-2019)
- PADI Open Water Diver