Ian Abraham

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Education

Ph.D. Candidate in Robotics — Evanston, IL
Center for Robotics and Biosystems, Northwestern University — *Sept. 2015 - Expected (Summer 2020)*

- **Topic**: Sensing, Learning, and Infinite Dimensional Structure
- **Advisor**: Todd D. Murphey

M.S. in Mechanical Engineering (Robotics) — Evanston, IL
Northwestern University — *Sept. 2015 - Dec. 2017*

- **Thesis**: Active Tactile Sensing for Object Shape and Localization using Ergodic Control

B.S in Mechanical and Aerospace Engineering, minor in Mathematics — New Brunswick, NJ
Rutgers University — *Sept. 2010 - May 2014*

- **Thesis**: Drift Simulation, Predictive Control, and Path Following of Autonomous Underwater Gliders

Research and Relevant Experience

Northwestern University — Evanston, IL
Graduate Researcher: Center for Robotics and Biosystems — *Sept. 2015 - Present*

- **Active Learning, Sensing, and Optimal Control**:
  Developed methods to enable optimal experimentation in robotic systems through physical interaction with the environment. Research primarily focused on developing online learning algorithms that intersect optimal control, learning theory, and hybrid systems theory.
- **DARPA FX-3 Urban Swarm Challenge**:
  Developed decentralized controllers for multi-agent robots with nonlinear dynamics. Enabled robot network interfaces for various forms of human-robot interaction for persistent and coordinated exploration that does not scale with increasing number of agents.
- **Active Tactile Sensing**:
  Improved sensing capabilities for robots with low-resolution (tactile) sensors and spatially sparse measurement information.

Advanced Semiconductor Materials Lithography (ASML) — Wilton, CT
Mechanical Design Engineer — *Oct. 2014 - Aug. 2015*

- **Ultra-Violet Level Sensor**:
  Implemented passive dynamic damping into sensor mechanical design and improved sensing performance through vibrational analysis.

Rutgers University — New Brunswick, NJ
Research Assistant: Robotics, Automation, and Mechatronics Lab (RAM) — *Aug. 2011 - May 2014*

- **Model-Predictive Control (MPC) of Buoyancy-Propelled Autonomous Underwater Gliders**:
  Modeled and implemented MPC strategy for the SLOCUM underwater glider using Antarctic deployment data.
- **(Team Lead) Nautical Explorer for Marine Operation (NEMO)**:
  Designed and constructed cost-efficient ($\sim$ \$1000) underwater glider with actuated wings. 3D printed custom parts and developed in-house circuits. Controller was extended from the model-based method used in the SLOCUM glider.

Publications

- **I. Abraham**, A. Handa, N. Ratliff, K. Lowrey, T.D. Murphey, D. Fox "Model-based Generalization under Parameter Uncertainty using Path Integral Control" in *IEEE Robotics and Automation Letters*, 2020 (Presenting at ICRA 2020 Paris)

- **I. Abraham** and T.D. Murphey "Active Learning of Dynamics for Data-Driven Control Using Koopman Operators, " in *IEEE Transactions on Robotics*, vol. 35, no. 5, pp. 1071-1083, Oct. 2019. (Presenting at ICRA 2020 Paris)

- **I. Abraham**, A. Prabhakar, T.D. Murphey, "Active Area Coverage from Equilibrium, " in *Workshop on Algorithmic Foundations of Robotics*, 2019. (Invited to Submit to Selective Journal)**(Oral)**

- **I. Abraham**, A. Mavromatti, T.D. Murphey, "Data-Driven Measurement models for Active Localization in Sparse Environments, " in *Robotics: Science and Systems*, 2018. **(Oral)(Poster)**

- A. Broad, **I. Abraham**, T.D. Murphey, B. Argall, "Structured Neural Network Dynamics for Model-based Control". Robotics: Science and Systems (RSS) Workshop on Learning and Inference in Robotics, 2018. **(Poster)**

- **I. Abraham** and T.D. Murphey, "Decentralized Ergodic Control: Distribution-Driven Sensing and Exploration for Multi-Agent Systems, " in *IEEE Robotics and Automation Letters*, 2018 . (Experimentally validated and utilized at DARPA FX-3)

- A. Mavrommati, E. Tzorakoleftherakis, **I. Abraham** and T. D. Murphey, "Real-Time Area Coverage and Target Localization Using Receding-Horizon Ergodic Exploration," in *IEEE Transactions on Robotics*, vol. 34, no. 1, pp. 62-80, 2018.

- **I. Abraham**, G. de la Torre, and T.D Murphey, "Model-based Control Using Koopman Operators," in *Robotics: Science and Systems*, 2017. (Invited to Submit to Selective Journal)**(Oral)(Poster)**

- **I. Abraham**, A. Prabhakar, M. J. Z. Hartmann and T. D. Murphey, "Ergodic Exploration Using Binary Sensing for Nonparametric Shape Estimation," in *IEEE Robotics and Automation Letters* , vol. 2, no. 2, pp. 827-834, 2017. (Presented at ICRA 2017 Singapore) **(Oral)(Poster)**

- **I. Abraham**, Z. Shen, and J. Seipel. A Nonlinear Leg Damping Model for the Prediction of Running Forces and Stability. *Journal of Computational and Nonlinear Dynamics*, 10(5), 051008 2015.

- **I. Abraham** and J. Yi, "Model Predictive Control of Buoyancy Propelled Autonomous Underwater Glider," *American Control Conference*, 2015, pp. 1181-1186. **(Oral)**

Submitted Manuscripts

- **I. Abraham**, A. Broad, A. Pinosky, B. Argall, T. D. Murphey, "Hybrid Control for Learning Motor Skills" in *Workshop on Algorithmic Foundations of Robotics*, (Submitted)

- **I. Abraham**, A. Prabhakar, T. D. Murphey, "Ergodic Measure for Active Learning From Equilibrium" in *IEEE Transactions on Automation Science and Engineering*, (Submitted)

- N.O. Zweifel, N.E. Bush, **I. Abraham**, T.D. Murphey, M.J.Z. Hartmann, "WHISKiT Physics: A three-dimensional mechanical model of the rat vibrissal array" in *PNAS*, (Submitted)

- A. Broad, **I. Abraham**, T.D. Murphey, B. Argall, "Data-driven Koopman Operators for Model-based Shared Control of Human-Machine Systems," *International Journal of Robotics Research* (Conditionally Accepted)

Teaching Experience

- T.A. for Machine Dynamics (ME 314) at Northwestern University, 2016

- Lecturer on Gaussian Processes for Active Learning (ME 495) at Northwestern University, 2018

- Lecturer (Neural Networks)/Grader for Machine Learning and Artificial Intelligence for Robotics (CS/ME 469) at Northwestern University, 2019

- Grader for Advanced Engineering Mathematics at Rutgers University, 2014

Professional Service

- Reviewer for *IEEE Transactions on Robotics* (T-RO)
- Reviewer for *IEEE International Conference on Robotics and Automation* (ICRA)
- Reviewer for *IEEE Robotics and Automation Letters* (RAL)
- Reviewer for *Robotics: Science and Systems* (R:SS)
- Reviewer for *Conference on Robot Learning* (CoRL)
- Reviewer for *IEEE International Conference on Intelligent Robotics and Systems* (IROS)

Technical Skills

- **Languages**: Python, C++, C, Matlab, LaTeX
- **Software**: ROS, OpenCV, Pytorch, Tensorflow, Jax (previously HIPS Autograd)
- **Robotic Platform**: Franka Emika Panda, Ghost Robotics Minitaur, Baxter (Rethink), Sawyer (Rethink), iRobot Create, SLOCUM Glider