Ian Abraham

https://i-abr.github.io
https://scholar.google.com/citations
Email : ianabraham21@gmail.com
Mobile : 201-467-6600

Education

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

- **Topic**: Optimal Experimental Learning and Infinite Linear Embeddings
- **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*

- **Sensing, Learning, and Optimal Control**:
  Developed formal methods for optimal robot learning and sensing for runtime active learning.
- **Active Tactile Sensing**:
  Improved sensing capabilities for robots with low-resolution (tactile) sensors and spatially sparse measurement information.

DARPA FX-3 Urban Swarm Challenge — Hattiesburg, MS
Graduate Researcher — *Dec. 2019*

- **Algorithmic Developer and Networking**:
  Developed and deployed ergodic decentralized controllers for robot swarm control and adaptation in urban environments. Enabled robot network interfaces for various forms of human-swarm interaction for persistent and coordinated exploration that does not scale with increasing number of agents.

NVIDIA Seattle Robotics Lab — Seattle, WA
Robotics Research Intern — *Oct. 2018 - Feb. 2019*

- **Robust Control for Kitchen Ready Robots**:
  Investigated stochastic optimal control methods with highly parallelizable simulators for enabling complex model-based control of robots for manipulation and locomotion under large parameter uncertainty.

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

- 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* (Accepted)
- **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)
- **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)**(2019 T-RO King-Sun Fu Best Paper Award)**
- **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)
- **I. Abraham**, A. Mavromatti, T.D. Murphey, "Data-Driven Measurement models for Active Localization in Sparse Environments, " in *Robotics: Science and Systems*, 2018.
- 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.
- **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)
- **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)
- **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.

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)

Honors and Awards

- **IEEE King-Sun Fu T-RO Best Paper Award**: 2019
- **Graduate Leadership and Service at Northwestern University**: 2016
- **Walter P. Murphy Doctoral Fellow at Northwestern University**: 2015
- **James J. Slade Scholar at Rutgers University**: 2013

Teaching Experience

- **Teaching Assistant**: Machine Dynamics at Northwestern University, 2016
- **Guest Lecture**: Gaussian Processes for Active Learning at Northwestern University, 2018, Neural Networks for Machine Learning and Artificial Intelligence for Robotics at Northwestern University, 2019

Leadership and Service

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

- **Jugando Con La Ciencia**: Gave talk about robot research to elementary school children in Spanish.
- **Robot Week at Museum of Science and Industry at Chicago**: Machine Dynamics at Northwestern University, 2016

Technical Skills

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