Ian Abraham

https://i-abr.github.io

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EMPLOYMENT

Carnegie Mellon University — Pittsburgh, PA
Postdoctoral Fellow at the Robotics Institute — *Aug. 2020 - Present*

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

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

EDUCATION

Ph.D. Mechanical Engineering — Evanston, IL
Center for Robotics and Biosystems, Northwestern University — *Sept. 2015 - July 2020*
- **Thesis** Optimal Experimental Learning and Infinite Linear Embeddings
- **Advisor** Todd D. Murphey

M.S. in Mechanical Engineering — 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 EXPERIENCE

Active Learning — Evanston, IL

Developed run-time active learning techniques for robotic systems. Illustrated fast learning capabilities with minimal human intervention.

DARPA FX-3 Urban Swarm Challenge — Hattiesburg, MS

Developed and deployed decentralized ergodic controllers for robot swarm control in urban environments for persistent search and rescue tasks.

Bio-inspired Sensing — Evanston, IL

Improved sensing capabilities for robots with low-resolution sensors. Assisted the development and experimental validation of a physics simulation for studying active sensing behavior in rats.

PUBLICATIONS

Journal Articles

[1] **I. Abraham**, A. Handa, N. Ratliff, K. Lowrey, T. D. Murphey, and D. Fox. "Model-Based Generalization Under Parameter Uncertainty Using Path Integral Control". In: *IEEE Robotics and Automation Letters* 5.2 (2020), pp. 2864–2871.

[2] **I. Abraham** and T. D. Murphey. "Active Learning of Dynamics for Data-driven Control using Koopman Operators". In: *IEEE Transactions on Robotics* 35.5 (2020), pp. 1071–1083.

[3] **I. Abraham**, A. Prabhakar, and T. D. Murphey. "An Ergodic Measure for Active Learning From Equilibrium". In: *IEEE Transactions on Automation Science and Engineering* (2020).

[4] A. Broad, **I. Abraham**, T. Murphey, and B. Argall. "Data-driven Koopman operators for model-based shared control of human–machine systems". In: *The International Journal of Robotics Research* (2020).

[5] **I. Abraham** and T. D. Murphey. "Decentralized ergodic control: distribution-driven sensing and exploration for multiagent systems". In: *IEEE Robotics and Automation Letters* 3.4 (2018), pp. 2987–2994.

[6] **I. Abraham**, A. Prabhakar, M. J. Hartmann, and T. D. Murphey. "Ergodic exploration using binary sensing for nonparametric shape estimation". In: *IEEE Robotics and Automation Letters* 2.2 (2017), pp. 827–834.

[7] 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* 34.1 (2017), pp. 62–80.

[8] **I. Abraham**, Z. Shen, and J. Seipel. "A nonlinear leg damping model for the prediction of running forces and stability". In: *Journal of Computational and Nonlinear Dynamics* 10.5 (2015).

Peer Reviewed Conference Papers

[9] **I. Abraham**, A. Broad, A. Pinosky, B. Argall, and T. D. Murphey. "Hybrid Control for Learning Motor Skills". In: *Workshop on the Algorithmic Foundations of Robotics*. 2020.

[10] A. Prabhakar, **I. Abraham**, A. Taylor, M. Schlafly, K. Popovic, G. Diniz, B. Teich, B. Simidchieva, S. Clark, and T. Murphey. "Ergodic Specifications for Flexible Swarm Control: From User Commands to Persistent Adaptation". In: *Robotics: Science and Systems*. 2020.

[11] **I. Abraham**, A. Prabhakar, and T. D. Murphey. "Active Area Coverage from Equilibrium". In: *Workshop on Algorithmic Foundations of Robotics*. 2019.

[12] **I. Abraham**, A. Mavrommati, and T. D. Murphey. "Data-Driven Measurement Models for Active Localization in Sparse Environments". In: *Robotics: Science and Systems*. 2018.

[13] **I. Abraham**, G. De La Torre, and T. D. Murphey. "Model-Based Control Using Koopman Operators". In: *Robotics: Science and Systems*. 2017.

[14] **I. Abraham** and J. Yi. "Model predictive control of buoyancy propelled autonomous underwater glider". In: *American Control Conference (ACC)*. 2015, pp. 1181–1186.

Editor Reviewed Book Chapters

[15]   T. A. Berrueta, **I. Abraham**, and T. Murphey. "Experimental Applications of the Koopman Operator in Active Learning". In: *The Koopman Operator in Systems and Control: Concepts, Methodologies, and Applications* 484 (2020), p. 421.

Workshop Papers and Preprints

[16]   G. Mamakoukas, **I. Abraham**, and T. D. Murphey. "Learning Stable Models for Prediction and Control". In: *arXiv preprint arXiv:2005.04291* (2020).

[17]   M. Rahme, **I. Abraham**, M. L. Elwin, and T. D. Murphey. "Dynamics and Domain Randomized Gait Modulation with Bezier Curves for Sim-to-Real Legged Locomotion". In: *arXiv preprint arXiv:2010.12070* (2020).

[18]   N. O. Zweifel, N. E. Bush, **I. Abraham**, T. D. Murphey, and M. J. Hartmann. "WHISKiT Physics: A three-dimensional mechanical model of the rat vibrissal array". In: *bioRxiv* (2019).

[19]   A. Broad[*], **I. Abraham**[*], T. Murphey, and B. Argall. "Structured neural network dynamics for model-based control". In: *Learning and Inference in Robotics – Robotics: Science and Systems* (2018).

OPEN SOURCE SOFTWARE AND DESIGNS

- **Spot Mini Mini:** https://github.com/OpenQuadruped/spot_mini_mini
  - An open source design of a Boston Dynamics inspirred quadruped robot for less than $600. Accompanied with an open source environment built using pybullet for sim-to-real robot locomotion tasks.

- **KL-Ergodic Exploration from Equilibrium (KL-E3):** https://github.com/i-abr/KLE3
  - Sample-based ergodic controller for active learning with stability constraints.

- **Active Learning using Koopman Operators:** https://github.com/i-abr/active-learning-koopman
  - Active learning controller for learning Koopman operator dynamic models.

- **Decentralized Ergodic Control:** https://github.com/i-abr/DecentralizedErgodicControl
  - Standalone ergodic controller for decentralized multi-agent systems.

HONORS AND AWARDS

- **IEEE King-Sun Fu T-RO Best Paper Award** 2020
- **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
- **Teaching Assistant** Machine Learning and Artificial Intelligence for Robotics at Northwestern, 2020
- **Guest Lecturer**
    * **Active Learning:** Nonparametric Methods and Gaussian Processes, Northwestern University, 2018
    * **Machine Learning and Artificial Intelligence for Robotics:** Neural Networks, Northwestern University, 2019
    * **Independent Study on Motion Planning Methods :** Dynamic Programming and Stochastic Optimal Control, Northwestern University, 2020

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 on research in robotics to elementary school children in Spanish.
- **National Robotics Week** Museum of Science and Industry at Chicago
- **Social Chair** M.E. Graduate Student Society, Northwestern University
- **Recruitment Chair** M.E. Graduate Student Society, Northwestern University