

ALEXANDER BROAD
alex.broad@u.northwestern.edu
www.alexanderbroad.com
Northwestern University, Chicago, IL

EDUCATION

Northwestern University School of Engineering and Applied Science, Evanston, IL
Doctoral Candidate in Computer Science, 2014 - Present (Expected Graduation June 2019)
Research Area: Machine Learning, Robotics, Control, Rehabilitation
Advisor: Brenna Argall

Washington University in St. Louis School of Engineering and Applied Science, St. Louis, MO
Master of Science in Computer Science, May 2011
Masters Thesis: Generating Muscle Driven Arm Movements Using Reinforcement Learning

Washington University in St. Louis College of Arts and Sciences, St. Louis, MO
Bachelor of Arts in Applied Mathematics and Philosophy-Neuroscience-Psychology (PNP), May 2009

HONORS AND AWARDS

Todd M. and Ruth Warren Fellowship (2014-2019) Highly selective 5-year fellowship for top computer science students

Northwestern University Terminal Year Fellowship (2019) Selective fellowship for PhD students in their terminal year

Walter P. Murphy Fellowship (2014) Fellowship for first year computer science students

IES Brain Research Foundation Grant (2008) Competitive grant for future brain research scientists (1 of 6 people awarded)

RESEARCH AND WORK EXPERIENCE

Northwestern University September 2014 - Present
Assistive and Rehabilitation Robotics Laboratory *PhD Research Assistant*

Mitsubishi Electronic Research Laboratories June 2017 - September 2017
Cambridge, MA *Machine Learning Research Intern*

- *Research Advisors:* Dr. Michael Jones, Dr. Teng-Yok Lee
- *Real-time Video Object Detection:* Developed and implemented novel deep neural network architecture to locate and classify objects in video data. The network architecture incorporates convolutional recurrent layers to extend standard image-based object detection frameworks to the video domain that is more common in robotics. The network was validated on numerous well known datasets and outperforms state-of-the-art single-frame baselines. The model is capable of running at 50Hz, fast enough for use in real-time systems.

MIT Lincoln Laboratory August 2011 - August 2014
Intelligence and Decision Technologies, Lexington, MA *Associate Technical Staff*

- *Information Provenance and Plagiarism Detection:* Developed and implemented a novel algorithm for plagiarism detection and document similarity. Adapted a Hidden Markov Support Vector Machine to learn a sequence tagger that can distinguish between instances of plagiarism and original content. Produced better than state-of-the-art results on established community dataset. Wrote tech report.
- *Automatic Path Planning for Flight Simulation:* Designed an open-loop controller for optimal path planning of a simulated aerial platform. Implemented efficient algorithm, capable of real-time updates to desired waypoints. Utilized various coordinate frames, including geocentric, geodetic and local, to accurately calculate updates for the platform's location in 4-dimensional space (latitude, longitude, elevation, heading). Developed simple interface allowing algorithm to be used on numerous subsequent projects.

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- *Mission Planning System*: Developed graphical user interface for a mission planning and data exploitation tool for U.S. military intelligence. Integrated advanced image processing algorithms with real time situational awareness to improve image analyst accuracy and efficiency. Worked closely with operational military intelligence to improve workflow and automate routine procedures. Designed the tool to integrate with pre-existing processing chain including complimentary tactile intelligence applications. Tested software with trained mission planners and image analysts and reported 2x increase in efficiency.

Washington University in St. Louis
Media and Machines Lab, St. Louis, MO

January 2010 - May 2011
Advisor : Professor Bill Smart

- *MS Thesis - Optimization of Complex Biomechanical Systems*: Researched motor control and optimization techniques to generate novel motion from first principles using reinforcement learning. Created biologically realistic model of hominoid arm using Stanfords open-source simulation software. Constructed evolutionarily motivated value function for reinforcement learning algorithm explicitly defined to optimize accuracy and minimize energy expenditure. Worked with Dr. Tom Erez to apply his receding-horizon optimization algorithm to simulated arm resulting in energy-efficient motor control system.

Washington University in St. Louis
Media and Machines Lab, St. Louis, MO

September 2008 - January 2009
Advisor : Professor Bill Smart

- *Human-Machine Interaction*: Researched methods for supervisory control of large mobile robot groups. Designed user interface models for use in directing robots.

JOURNAL PUBLICATIONS

- Broad, A., Arkin, J., Ratliff, N., Howard, T., Argall, B. “Real-Time Natural Language Corrections for Assistive Robotic Manipulators”. *International Journal of Robotics Research (IJRR)*. 2017.
- Broad, A., Schultz, J., Derry, M., Murphey, T., Argall, B. “Trust Adaptation Leads to Lower Control Effort in Shared Control of Crane Automation”. *IEEE Robotics and Automation Letters (RA-L)*. 2016. Also presented at the 12th IEEE Conference on Automation Science and Engineering (CASE).

REFEREED CONFERENCE PUBLICATIONS

- Broad, A., Murphey, T., Argall, B. “Operation and Imitation under Safety-Aware Shared Control”. *Workshop on the Algorithmic Foundations of Robotics (WAFR)*. 2018.
- Broad, A., Jones, M., Lee, T-Y. “Recurrent Multi-frame Single Shot Detector for Video Object Detection”. *British Machine Vision Conference (BMVC)*. 2018.
- Broad, A., Murphey, T., Argall, B. “Learning Models for Shared Control of Human-Machine Systems with Unknown Dynamics”. *Robotics: Science and Systems (RSS)*. 2017.
- Broad, A., Argall, B. “Path Planning under Kinematic Constraints for Assistive Robotics”. *International Conference on Planning and Scheduling (ICAPS)*. 2016.
- Jain, S., Farshchiansadegh, A., Broad, A., Abdollahi, F., Mussa-Ivaldi, F., Argall, B. “Assistive Robotic Manipulation through Shared Autonomy and a Body-Machine Interface.” *IEEE International Conference on Rehabilitation Robotics (ICORR)*. 2015.

REFEREED WORKSHOP PUBLICATIONS

- Broad, A., Murphey, T., Argall, B. “Demonstration and Imitation of Novel Behaviors under Safety Aware Shared Control”. *Robotics: Science and Systems (RSS) Workshop on Causal Imitation in Robotics*. 2018.
- Broad, A., Abraham, I., Murphey, T., Argall, B. “Structured Neural Network Dynamics for Model-based Control”. *Robotics: Science and Systems (RSS) Workshop on Learning and Inference in Robotics*. 2018.
- Broad, A., Gopinath, D., Murphey, T., Argall, B. “An Empirical Analysis of Methods for Learning Robot Kinematics from Demonstration”. *Midwest Robotics Workshop (MWRW)*. 2017.

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- Broad, A., Arkin, J., Ratliff, N., Howard, T., Argall, B. “Towards Real-Time Natural Language Corrections for Assistive Robots”. Robotics: Science and Systems (RSS) Workshop on Model Learning for Human-Robot Communication. 2016.
- Broad, A., Argall, B. “Geometry-Based Region Proposals for Accelerated Image-Based Detection of 3D Objects”. Robotics: Science and Systems (RSS) Workshop on Deep Learning. 2016.
- Broad, A., Derry, M., Schutlz, J., Murphey, T., Argall, B. “Inverted Trust Improves Shared Control of Complex Dynamic Systems”. Robotics: Science and Systems (RSS) Workshop on Social Trust in Autonomous Robots. 2016.
- Arkin, J., Broad, A., Ratliff, N., Howard, T., Argall, B. “Probabilistic Models for Real-Time Natural Language Corrections to Assistive Robotic Manipulators”. Midwest Robotics Workshop (MWRW). 2016.

MANUSCRIPTS IN PROGRESS

- Broad, A., Abraham, I., Murphey, T., Argall, B. “Model-based Shared Control of Data-Driven Human-Machine Systems”. Submitted to Journal.
- Abraham, I., Broad, A., Argall, B., Murphey, T. “Switching Mode Policy Optimization”. In Preparation for Conference Submission.
- Broad, A., Argall, B. “Geometry-Based Region Proposals for Real-Time Robot Detection of Tabletop Objects”. Under Review in Autonomous Robots.

ORAL PRESENTATIONS

- “Data-Driven Shared Control for Assistive Robotics” SPIE-MRSEC Student Seminar Series. Northwestern University. 2018.
- “Learning Models for Shared Control of Human-Machine Systems with Unknown Dynamics”. Robotics: Science and Systems (RSS). Massachusetts Institute of Technology. 2017.
- “Path Planning under Kinematic Constraints for Assistive Robotics”. International Conference on Planning and Scheduling (ICAPS). King’s College London. 2016.
- “Towards Real-Time Natural Language Corrections for Assistive Robots”. Robotics: Science and Systems (RSS). University of Michigan. 2016.
- “Geometry-Based Region Proposals for Accelerated Image-Based Detection of 3D Objects”. Robotics: Science and Systems (RSS). University of Michigan. 2016.

POSTER PRESENTATIONS

- “Demonstration and Imitation of Novel Behaviors under Safety Aware Shared Control”. Workshop at Robotics: Science and Systems (RSS). Carnegie Mellon University. 2018.
- “Structured Neural Network Dynamics for Model-based Control”. Workshop at Robotics: Science and Systems (RSS). Carnegie Mellon University. 2018.
- “An Empirical Analysis of Methods for Learning Robot Kinematics from Demonstration”. Midwest Robotics Workshop (MWRW). University of Chicago. 2017.
- “Inverted Trust Improves Shared Control of Complex Dynamic Systems”. Workshop at Robotics: Science and Systems (RSS). University of Michigan. 2016.
- “Probabilistic Models for Real-Time Natural Language Corrections to Assistive Robotic Manipulators”. Midwest Robotics Workshop (MWRW). University of Chicago. 2016.

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TEACHING EXPERIENCE

- T.A. for Introduction to Robotics Laboratory (EECS 301) at Northwestern University. 2015, 2016.
- T.A. for Programming Systems and Languages (CSE 425S) at Washington University in St. Louis. 2010.
- T.A. for Logic and Discrete Mathematics (CSE 240) at Washington University in St. Louis. 2010.

PROFESSIONAL SERVICE

- Reviewer for Autonomous Robotics (AURO) - 2018
- Reviewer for Robotics and Automation Letters (RA-L) - 2017
- Reviewer for the International Conference on Robotics Automation (ICRA) - 2017
- Reviewer for Transactions on Robotics (T-RO) - 2016
- Reviewer for the International Conference on Robotics Automation (ICRA) - 2016
- Reviewer for the International Conference on Intelligent Robots and Systems (I-ROS) - 2016
- Reviewer for the International Conference on Intelligent Robots and Systems (I-ROS) - 2015

TECHNICAL SKILLS

- Languages: Python, C++, Java, Matlab, Scheme, Mathematica
- Packages: ROS, Tensorflow, PyTorch, Keras, NumPy, SciPy, Dlib
- Productivity: Git, L^AT_EX