Alexander "Sasha" Lambert

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RESEARCH INTERESTS

Imitation Learning · Stochastic Optimal Control · Reinforcement Learning · Variational Inference · Probabilistic Robotics · Motion Planning · Robot Manipulation · Grasping · Perception · Sensor Fusion

EDUCATION

Ph.D Robotics 2015 – 2021
Advisor: Byron Boots
Committee: Seth Hutchinson, Fabio Ramos, Sonia Chernova, Matthew Gombolay
Georgia Institute of Technology, Atlanta, GA

M.S. Aerospace Engineering with Thesis 2010 – 2012
Georgia Institute of Technology, Atlanta, GA

B.Eng Mechanical Engineering with Honors 2006 – 2010
McGill University, Montreal, QC, Canada

RESEARCH EXPERIENCE

University of Washington 2021-present
Post-doctoral Fellow
Seattle, Washington
Collaborators: Byron Boots, Dieter Fox, Siddhartha S. Srinivasa

RACER: High-Speed Autonomous Off-Road Driving

- Working on the UW team (one of three teams in the country) for the DARPA-sponsored RACER program ("Robotic Autonomy in Complex Environments with Resiliency").
- The objective is to match human-expert level performance for high-speed driving in unstructured outdoor environments under various conditions. This is being conducted on Polaris RZR off-road vehicles, outfitted with state-of-the-art computing and sensing capabilities.
- The competitions take place in desert-like and forested environments, complete with vegetated, sloped and rocky terrain features.

Learning Complex Terrain Maneuvers from Demonstration

- Off-road autonomous vehicles must maneuver through thick vegetation, forested areas and rough terrain. However, it is difficult to define what is traversible, given such unstructured and variable environments. A planner's anticipated interaction with such local terrain features can be represented by a cost-map. This can depend on the current planning context, such as the layout of surrounding scene with respect to the robot or relative goal location.
- The approach combines Inverse Reinforcement Learning (IRL) and semantic segmentation to learn traversability cost-maps from user demonstrations. Testing and deployment is being conducted on a Clearpath Warthog, an autonomous ground robot.

Stein Variational Probabilistic Roadmaps

- A global path-planning algorithm leveraging non-parametric variational inference was developed for Bayesian occupancy maps and differentiable cost functions.
- The approach demonstrated improved performance on both simulated and real-world motion planning problems, when compared to conventional sampling-based planners.
- Improved sampling efficiency was observed for both navigation and manipulation tasks, resulting in higher success rates and lower-cost solutions.

University of Washington 2020-2021
Visiting Graduate Researcher
Seattle, Washington
Collaborators: Byron Boots, Fabio Ramos, Dieter Fox

Entropy-Regularized Trajectory Optimization with Stein Variational Inference

- A motion-planning algorithm was developed, leveraging particle-based variational inference and structured trajectory priors for probabilistic optimization over a finite horizon.
- Given a differentiable cost and stochastic dynamics, a distribution of smooth planning trajectories can be recovered for goal-oriented tasks on high-dof systems.
- This method can be used for value-function approximation in entropy-regularized formulations of model-based reinforcement learning for stochastic system dynamics and continuous control, or provide a distribution of expert trajectories to be used for imitation learning and related approaches.

Online Model Adaptation and Uncertainty Estimation for Model Predictive Control

- Developed a particle-based variational inference technique for dynamics parameter estimation, which can be used for online system identification.
- A multi-modal model predictive control algorithm was adapted to incorporate the non-parametric uncertainty uncertainty model.
- The approach was tested on a skid-steer autonomous ground vehicle with uncertain mass loading and unexpected dynamic perturbations.

NVIDIA Robotics Research - Intern Summer 2018, Summer 2019 - Spring 2020
Seattle, Washington
Collaborators: Fabio Ramos, Nathan Ratliff, Byron Boots, Dieter Fox

Variational Inference for Planning and Stochastic Optimal Control

- A general Bayesian framework for multi-modal model predictive control and planning was developed, leveraging particle-based representations for distributed online inference.
- The approach was demonstrated on navigation and high degree of freedom manipulation tasks, using fully parallelized physics simulators.

Under-actuated Manipulation with Path Integral Control

- An adaptive optimization algorithm for sampling-based model-predictive control was developed for articulated swing-up and balancing tasks.
- The integration of structured priors and and goal-driven entropy regulation was used to achieve dynamic manipulation on a simulated Kuka LBR robot.

Learning Robust Models for Tactile Force Estimation

- A supervised learning technique was developed to train a parametrized model for predicting contact point and force normals from a biomimetic tactile .
- An automated data collection pipeline was configured using both a Yumi Robot and a Kuka LBR manipulator, along with depth-based tracking for pose estimation.

Honda Research Institute - Intern Summer 2017
Mountainview, California
Collaborators: Yi-Ting Chen

Multi-Object Tracking and Scene Reconstruction

- Given RGB and Lidar data collected from a moving vehicle, state estimation and tracking were performed on dynamic objects in the scene, including pedestrians and other vehicles.
- Probabilistic filters and deep recurrent models were combined within a multi-hypothesis tracking framework for associating observations to objects. This allowed for improved segmentation and reconstruction of dynamic objects from SLAM-derived 3D maps.

Georgia Institute of Technology 2016-2018
Graduate Research Assistant
Collaborators: Byron Boots

Joint Inference for Multi-Modal Sensing and Manipulation

- A method was developed for fusing visual and tactile sensor modalities to enhance perception in robot manipulation tasks.
- Sensor-model learning and model-based tracking were combined in a probabilistic estimation framework, integrating physics-based and geometric priors for robust performance in cluttered scenes.

Flow-Based Visual Prediction and Occlusion Detection

- Developed a hybrid parametric/non-parametric generative model for high-resolution camera images. The approach learned a blended inverse flow-field for transforming key-frame observations from different robot poses.
- This improved visual prediction of desired joint-space trajectories, when compared to standard baselines. The approach was extended for probabilistic tracking, as well as detecting occlusions in cluttered scenes.

Georgia Institute of Technology 2013-2015
Research Engineer
Collaborators: Henrik Christensen, Fecundo Fernandez

Vision-based Control for Industrial Manipulators

- The Aerospace industry is investing heavily in intelligent manufacturing automation to increase production agility. We developed a vision-guided control system for fixtureless wing assembly drilling and inspection using different robot manipulators (UR5, Kuka KR210, KR500)
- A two-tiered vision system was designed, consisting of a model-based object tracker for global part localization, and eye-in-hand high-resolution feature-tracking for accurate visual servoing.
- Sponsored by Boeing Research & Technology.

Robotic Surface Analysis Mass Spectrometry for 3-D Geometries

- Developed an automated system to perform native sampling of organic tissue and geological material for mass spectral (MS) analysis. A UR5 robot arm was used to scan a target bulk sample with an RGB-D sensor, generating a pointcloud surface from which to select sampling locations.
- An end-effector probe could then be used to derive material and perform MS analysis in-situ. This approach provided the analyst with spatial correlations to the data and the capability to produce a 3-dimensional chemical map of the sample.

PUBLICATIONS

Pre-prints

A. Lambert*, A. Le*, J. Urain*, G. Chalvatzaki, B. Boots, J. Peters. "Learning Implicit Priors for Motion Optimization" *International Conference on Intelligent Robots and Systems (IROS)*. 2022.

Conference Publications

A. Lambert, B. Hou, R. Scalise, S. Srinivasa, B. Boots. "Stein Variational Probabilistic Roadmaps" *International Conference on Robotics and Automation (ICRA)*. 2022.

L. Barcelos, **A. Lambert**, R. Oliveira, P. Borges, B. Boots, F. Ramos. "Dual Online Stein Variational Inference for Control and Dynamics". *Robotics: Science and Systems (RSS)*. 2021

A. Lambert, A. Fishman, D. Fox, B. Boots, F. Ramos. "Stein Variational Model Predictive Control" *Conference on Robot Learning (CoRL)*. 2020

A. Lambert, M. Mukadam, B. Sundaralingam, N. Ratliff, B. Boots, D. Fox. "Joint Inference of Physics-Based Tracking and Force Estimation in Planar Pushing" *International Conference on Robotics and Automation (ICRA)*. 2019

B. Sundaralingam, **A. Lambert**, A. Handa, B. Boots, T. Hermans, S. Birchfield, N. Ratliff, D. Fox. "Robust Learning of Tactile Force Estimation through Robot Interaction" *International Conference on Robotics and Automation (ICRA)*. 2019. **Finalist - Best Paper in Robot Manipulation**

A. Lambert, A. Shaban, A. Raj, Z. Liu, and B. Boots. "Deep Forward and Inverse Perceptual Models for Tracking and Prediction." *International Conference on Robotics and Automation (ICRA)*. 2018.

B. Sforzo, J. Kim, **A. Lambert**, J. Jagoda, S. Menon, J. Seitzman. "High Energy Spark Kernel Evolution: Measurements and Modeling." *8th US National Combustion Meeting*. 2013.

Journal Publications

B. Sforzo, **A. Lambert**, J. Kim, J. Jagoda, S. Menon, J. Seitzman. "Post discharge evolution of a spark igniter kernel." *Combustion and Flame*. 2015.

Refereed Workshop Papers

A. Lambert, B. Boots. "Entropy Regularized Motion Planning via Stein Variational Inference." *Workshop on Integrating Planning and Learning (RSS)*. 2021

A. Lambert, A. Fishman, D. Fox, B. Boots, F. Ramos. "Stein Variational Model Predictive Control." *Structured Approaches to Robot Learning for Improved Generalization (RSS)*. 2020

A. Lambert, A. Fishman, D. Fox, B. Boots, F. Ramos. "Stein Variational Model Predictive Control." *Fourth Machine Learning in Planning and Control of Robot Motion Workshop (ICRA)*. 2020

A. Lambert, A. Shaban, A. Raj, Z. Liu, and B. Boots. "Deep Perceptual Models for Tracking and Prediction." New Frontiers for Deep Learning in Robotics. *Robotics: Science and Systems (RSS)*. 2017.

A. Lambert, A. Shaban, A. Raj, Z. Liu, and B. Boots. "Deep Perceptual Models for Tracking and Prediction." Workshop on Articulated Model Tracking. *Robotics: Science and Systems (RSS)*. 2017.

PATENTS

- "Force Estimation Using Deep Learning". Filed: Mar. 19, 2019. Pub. Date: Sept. 24, 2020. Pub. No.: US 2020/0301510 A1.
- "Model Predictive Control Techniques for Autonomous Systems". Filed: Apr. 28, 2020. Pub. Date: Oct. 28, 2021. Pub. No.: US 2021/0334630 A1.

HONORS

RSS Pioneer 2021

Selected to the Robotics Science and Systems pioneers cohort of 2021, a group of 30 leading senior PhD students and postdocs in the field.

Best Paper in Robot Manipulation (Finalist) 2019
ICRA 2019

FQRNT Doctoral Scholarship 2016-2017
Science and Engineering Research Foundation of Quebec

Undergraduate Student Research Award 2008-2009
Natural Sciences and Engineering Research Council (NSERC)

Undergratuate Research in Engineering Award 2007-2008
McGill University

LEADERSHIP AND PROFESSIONAL SERVICE

Mentorship

- Brian Lee (M.S. student, Robot Learning Lab @ University of Washington)
- Rosario Scalise (Ph.D student, Robot Learning Lab @ University of Washington)
- An T. Le (Ph.D student, Intelligent Autonomous Systems Lab @ TU Darmstadt)
- Lucas Barcelos (Ph.D student, University of Sydney)
- Zhen Liu (Undergraduate student @ Georgia Tech)

Coordinator

Institute for Robotics and Intelligent Machines, Georgia Institute of Technology

- National Robotics Week : 2014 – 2015
  - Organized lab tours and provided demos for high-school and elementary students.
- RoboGrads service : 2014 – 2017
  - Assisted in organizing recruitment events for potential and incoming Ph.D students.
  - Hosted visiting seminar speakers and faculty candidates.

Reviewer

- Conference on Robot Learning (CoRL)
- IEEE Robotics and Automation Letters (RA-L)
- IEEE International Conference on Robotics and Automation (ICRA)
- IEEE-RAS International Conference on Humanoid Robots (Humanoids)
- NeurIPS Workshop on Imitation Learning and its Challenges in Robotics

TEACHING EXPERIENCE

Head Teaching Assistant 2016-2017
CS 7641 - Machine Learning
Udacity - Georgia Tech Master's in CS (MOOC program)
Instructors : Prof. Charles Isbell & Prof. Michael Littman

CERTIFICATIONS

KUKA College - Programming I (KSS 8.x) June 2015
Kuka Systems North America

TECHNICAL SKILLS

Programming Languages: C++, Python, MATLAB, Java, KRL (Kuka), Fortran
Libraries: Pytorch, Torchscript, TensorFlow, ROS, Gazebo, OpenCV, PCL, SciKit-Learn, Pandas
CAD Software: Solidworks, ANSYS