Balakumar Sundaralingam

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Education

University of Utah — Salt Lake City, UT, USA
Ph.D. Computing (Robotics) — 2014 - 2020
Thesis: "Kinematic Planning and Dynamics Inference for In-Hand Manipulation"
Committee: Tucker Hermans(**advisor**), John Hollerbach, Srikumar Ramalingam, Vivek Srikumar, and Kris Hauser(University of Illinois at Urbana-Champaign).

SASTRA University — Thanjavur, TN, India
B.Tech in Mechatronics, First class with distinction — 2009 - 2013

Research/Work Experience

Dexterous Manipulation — University of Utah
Research assistant, Publications:[1-3, 8-12] — 2015-2020
Mentor: Prof. Tucker Hermans

- Dissertation research focuses on multi-fingered in-hand manipulation of unknown objects.
- Researched & empirically validated a kinematic trajectory optimization scheme for reposing a grasped object via in-hand manipulation without requiring object dynamics knowledge.
- Explored estimation of object dynamics in-hand leveraging tactile sensing and inference in a factor graph.
- Disseminated my research at public venues through invited talks.

Perception for Manipulation — NVIDIA Seattle Robotics Lab
Robotics research intern, Publications:[3-7] — Summer 2018
Mentors: Prof. Dieter Fox, Dr. Nathan Ratliff, Dr. Ankur Handa, Prof. Stan Birchfield

- Researched a novel data collection paradigm for tactile sensors, enabling excitation of sensor dynamics and accurate measurement of small scale forces.
- Developed a neural network architecture that encodes the geometry of the tactile sensor signals.
- Integrating the novel data collection paradigm and geometric neural network resulted in a highly accurate force estimation model for the BioTac sensor. This research was a **finalist for the Best Manipulation Paper award at ICRA 2019**.
- Collaborated with researchers working on projects related to object pose estimation, state estimation via tactile force sensing, and learning from demonstration for tactile servoing.

Reactive Collision Avoidance for Quadrotors & Mobile robots — University of Utah
Graduate assistant, DARC Lab, Mentor: Prof. Kam K. Leang — 2014-2015

- Built holonomic mobile robot platform with 2D LIDAR and investigated local minima problems existent with state-of-the art reactive collision avoidance methods.

Mapping by LIDAR Scan Matching — SASTRA University
Undergraduate Thesis, Mobile Robotics Lab, Mentor: Prof. Prem S. — 2012-2013

- Implemented and extended line extraction algorithms (Split and Merge methods) to perform mapping by iterative line matching between LIDAR scans.
- Setup data collection pipeline for the Pioneer3AT robot to analyze existing mapping methods.

Development Experience (C++, Python)

Full stack development for autonomous dexterous manipulation system (URL), key contributions being:

- Developed real-time low-level joint controllers in the OROCOS framework with robot dynamics compensation using KDL for the KUKA LBR4 arm and the Allegro hand.
- Built in-house collision checking APIs, combining several collision checking libraries for fast and accurate signed distance measurements on polygon meshes.
- Extensive implementation of manipulation planning tools with integration to in-house collision checking APIs, grasp force-closure computation on polygon meshes, and joint space trajectory optimization.
- Setup perception system to detect and track the environment and the robot, enabling feedback for real world manipulation tasks.
- Integrated tactile sensors for dynamics inference through factor graphs using GTSAM.
- Developed software tools to estimate & calibrate robot's kinematic and dynamics parameters.

Publications

1. B. Sundaralingam and T. Hermans, **Relaxed-Rigidity Constraints: In-Grasp Manipulation using Purely Kinematic Trajectory Optimization**, *Robotics: Science and Systems (RSS)*, 2017
2. Q. Lu, K. Chenna, B. Sundaralingam, and T. Hermans, **Planning Multi-Fingered Grasps as Probabilistic Inference in a Learned Deep Network**, *International Symposium on Robotics Research*, 2017
3. B. Sundaralingam and T. Hermans, **Geometric In-Hand Regrasp Planning: Alternating Optimization of Finger Gaits and In-Grasp Manipulation**, *IEEE Intl. Conf. on Robotics and Automation*, 2018
4. J. Tremblay, T. To, B. Sundaralingam, Y. Xiang, D. Fox, and S. Birchfield, **Deep Object Pose Estimation for Semantic Robotic Grasping of Household Objects**, *Conference on Robot Learning*, 2018
5. B. Sundaralingam, A. Lambert, A. Handa, B. Boots, T. Hermans, S. Birchfield, N. Ratliff, and D. Fox, **Robust Learning of Tactile Force Estimation through Robot Interaction (Best Paper in Robot Manipulation Award–Finalist)**, *IEEE Intl. Conf. on Robotics and Automation*, 2019
6. A. Lambert, M. Mukadam, B. Sundaralingam, N. Ratliff, B. Boots, and D. Fox., **Joint Inference of Kinematic and Force Trajectories with Visuo-Tactile Sensing**, in *IEEE Intl. Conf. on Robotics and Automation*, 2019
7. G. Sutanto, N. Ratliff, B. Sundaralingam, Y. Chebotar, Z. Su, A. Handa, and D. Fox, **Learning Latent Space Dynamics for Tactile Servoing**, *IEEE Intl. Conf. on Robotics and Automation*, 2019
8. B. Sundaralingam and T. Hermans, **Relaxed-rigidity constraints: kinematic trajectory optimization and collision avoidance for in-grasp manipulation**, *Autonomous Robots*, 2019
9. S. Cruciani*, B. Sundaralingam*, K. Hang, V. Kumar, T. Hermans, and D. Kragic, **Benchmarking In-Hand Manipulation(*equal contribution)**, *IEEE Robotics and Automation Letters*, 2019
10. M. V. der Merwe, Q. Lu, B. Sundaralingam, M. Matak, and T. Hermans, **Learning Continuous 3D Reconstructions for Geometrically Aware Grasping**, *IEEE Intl. Conf. on Robotics and Automation*, 2020
11. Q. Lu, M. V. der Merwe, B. Sundaralingam, and T. Hermans, **Multi-Fingered Grasp Planning via Inference in Deep Neural Networks**, *IEEE Robotics & Automation Magazine*, 2020
12. B. Sundaralingam and T. Hermans, **In-Hand Object-Dynamics Inference using Tactile Fingertips**, *CoRR*, vol. abs/2003.13165, 2020