Balakumar Sundaralingam

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Education

University of Utah	Salt Lake City, UT, USA
Ph.D. Candidate in Computing: Robotics Track, Cum. GPA: 3.8/4	2014-Present
SASTRA University	Thanjavur, TN, India
B.Tech in Mechatronics, First class with distinction, Cum. GPA: 7.8/10	2009-2013

Research Experience

Dexterous Manipulation — University of Utah
Research assistant, LL4MA Lab, Publications:[1-3,5] — 2015-Present
Mentor: **Prof**. **Tucker Hermans**

- Exploring multi-fingered dexterous manipulation of objects without extensive object models.
- Leveraging gradient based optimization for joint space robot motion planning.
- Developed a kinematic trajectory optimization scheme for in-hand reposing of a grasped object, with no dropping of the object during 500 real world experiments with YCB objects.
- Explored sequence planning for reposing a grasped object by fingertip relocation and object reposing.
- Recently started working on trajectory optimization through SQP (sequential quadratic program) for stable grasping and object information inference from tactile perception.

Tactile Manipulation — NVIDIA Seattle Robotics Lab
Robotics research intern, NVIDIA Research, Publications:[4,6-8] — May 2018-Aug 2018
Mentors: **Prof**. **Dieter Fox**, **Dr**. **Nathan Ratliff**, **Dr**. **Ankur Handa**, **Prof**. **Stan Birchfield**

- Trained a neural network for supervised learning of tactile force model to map tactile signals to force, with validation on robot manipulation task (video).
- Collaborated on projects related to object pose estimation, probabilistic graphical models for state estimation and learning from demonstration for tactile servoing.

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

- Built holonomic mobile robot platform to study collision avoidance methods.
- Explored local minima problems existent with reactive collision avoidance approaches.

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

- Developed algorithm for estimating transformation between consecutive LIDAR scans.
- Implemented line extraction algorithms(Split and Merge methods) to extract lines from LIDAR points.

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," *ISRR*, 2017

3. **B**. **Sundaralingam** and T. Hermans, "Geometric in-hand regrasp planning: Alternating optimization of finger gaits and in-grasp manipulation," *ICRA*, 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," *CoRL*, 2018

5. **B**. **Sundaralingam** and T. Hermans, "Relaxed-rigidity constraints: kinematic trajectory optimization and collision avoidance for in-grasp manipulation," *Autonomous Robots (AuRo)*, 2019

6. **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 Manipulation Paper Finalist**, ICRA*, 2019

7. 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 *ICRA*, 2019

8. G. Sutanto, N. Ratliff, **B. Sundaralingam**, Y. Chebotar, Z. Su, A. Handa, and D. Fox, "Learning latent space dynamics for tactile servoing," *ICRA*, 2019

Development Experience (C++,Python)

Hardware platforms: Pioneer 3AT, KUKA LWR4+, Franka Panda, Baxter, Allegro hand, Reflex hand.

Robot control interface: Developed low-level real-time controllers for the Allegro hand and the KUKA lbr4 robot with FRI and KDL.

Simulation: Familiar with Vrep, Gazebo and KLAMPt for simulation of manipulators and mobile robots.

Signed distance library: Explored signed distance computation from RGB-D sensor data. Implemented C++ perception library to compute signed distance(GJK+EPA) between objects by convex decomposition. Coded a C++ wrapper to work with FCL, libccd and KRISLibrary for collision checking.

Trajectory optimization: Implemented collision-free motion planners for manipulators by formulating SQPs with cost terms minimizing collisions with the environment (video).

Mobile robot collision avoidance: Investigated current reactive collision avoidance methods for holonomic mobile robots. Artificial potential field and vector polar histogram algorithms were implemented with a 2D LIDAR. Optic flow of sift features between frames from a monocular camera was also implemented to detect and avoid nearby obstacles (video).

Teaching Experience

Created and conducted labs on robotic platforms, mentored by **Prof**. **John Hollerbach**

Intro. **to Robotics**: DH parameter computation, Forward and Inverse kinematics, and trajectory smoothing with the Baxter and KUKA robots.

System Identification for Robots: Kinematic and dynamic parameter estimation of the Baxter robot links and tools.