

## Balakumar Sundaralingam

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### Education

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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

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#### 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

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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)

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**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

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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.