Balakumar Sundaralingam

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Education

University of Utah — Salt Lake City, UT, USA
Ph.D. in Computing(Robotics) — 2014 - 2020

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

Research/Work Experience

Senior Research Scientist — NVIDIA
Robotics Research — 2020 - Present

- Led a multi-year research effort to build cuRobo, a GPU accelerated library for robotics that solves global motion planning as a trajectory optimization problem 60x faster on the GPU. The obtained trajectories have higher quality (6x lower jerk) and 25% faster motion time. This effort included contributions from several researchers and engineers across NVIDIA. This research has been tech-transferred, available as Isaac ROS cuMotion.
- Researched a novel model predictive control framework STORM for manipulators that leverages sampling-based optimization and GPU compute for fast collision-free control over learned cost and value functions. Extended this work to support motion corrections with language, collision avoidance from NERF, and grasping objects from humans.
- Developed several algorithms (kinematics, signed distance, numerical solvers) to run efficiently on GPU with CUDA-level programming and also designed user-level APIs for use across robotics problems.
- Significant experience in robotic systems, work with engineering and product teams on various problems.
- Mentored several interns, organized internal talks, and contributed to conferences via reviewing and associate editor roles.

Research Assistant — University of Utah
Dexterous Manipulation — 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.

Robotics Research Intern — NVIDIA Seattle Robotics Lab
Perception for Manipulation — 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.

Graduate Assistant University of Utah
Reactive Collision Avoidance, 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.

Undergraduate Thesis SASTRA University
Mapping by LIDAR Scan Matching, 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.

Peer-reviewed Conference Papers

1. J. Pavlasek, S. R. Lewis, B. Sundaralingam, F. Ramos, and T. Hermans, Ready, set, plan! planning to goal sets using generalized bayesian inference, in *Conference on Robot Learning*, pp. 3672–3686, PMLR, 2023
2. Y.-S. Hsiao, S. K. S. Hari, B. Sundaralingam, J. Yik, T. Tambe, C. Sakr, S. W. Keckler, and V. J. Reddi, Vapr: Variable-precision tensors to accelerate robot motion planning, in *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 6304–6309, IEEE, 2023
3. B. Sundaralingam, S. K. S. Hari, A. Fishman, C. Garrett, K. Van Wyk, V. Blukis, A. Millane, H. Oleynikova, A. Handa, F. Ramos, *et al.*, Curobo: Parallelized collision-free robot motion generation, in *2023 IEEE International Conference on Robotics and Automation (ICRA)*, pp. 8112–8119, IEEE, 2023
4. A. Handa, A. Allshire, V. Makoviychuk, A. Petrenko, R. Singh, J. Liu, D. Makoviichuk, K. Van Wyk, A. Zhurkevich, B. Sundaralingam, *et al.*, Dextreme: Transfer of agile in-hand manipulation from simulation to reality, in *2023 IEEE International Conference on Robotics and Automation (ICRA)*, pp. 5977–5984, IEEE, 2023
5. Z. Tang, B. Sundaralingam, J. Tremblay, B. Wen, Y. Yuan, S. Tyree, C. Loop, A. Schwing, and S. Birchfield, Rgb-only reconstruction of tabletop scenes for collision-free manipulator control, in *IEEE Intl. Conf. on Robotics and Automation*, pp. 1778–1785, IEEE, 2023
6. P. Sharma, B. Sundaralingam, V. Blukis, C. Paxton, T. Hermans, A. Torralba, J. Andreas, and D. Fox, Correcting robot plans with natural language feedback, in *Proceedings of Robotics: Science and Systems*, 2022
7. W. Yang*, B. Sundaralingam*, C. Paxton*, I. Akinola, Y.-W. Chao, M. Cakmak, and D. Fox, Model predictive control for fluid human-to-robot handovers(*equal contribution), in *IEEE Intl. Conf. on Robotics and Automation*, 2022
8. Y.-W. Chao, C. Paxton, Y. Xiang, W. Yang, B. Sundaralingam, T. Chen, A. Murali, M. Cakmak, and D. Fox, Handoversim: A simulation framework and benchmark for human-to-robot object handovers, in *IEEE Intl. Conf. on Robotics and Automation*, 2022
9. M. Bhardwaj, B. Sundaralingam, A. Mousavian, N. D. Ratliff, D. Fox, F. Ramos, and B. Boots, Storm: An integrated framework for fast joint-space model-predictive control for reactive manipulation, in *Proceedings of the 5th Conference on Robot Learning*, vol. 164 of *Proceedings of Machine Learning Research*, pp. 750–759, PMLR, 08–11 Nov 2022, **Selected for Oral Presentation (6.5% acceptance rate)**
10. Y. Narang*, B. Sundaralingam*, M. Macklin, A. Mousavian, and D. Fox, Sim-to-real for robotic tactile sensing via physics-based simulation and learned latent projections (*equal contribution), *IEEE Intl. Conf. on Robotics and Automation*, 2021

11. V. Kumar, D. Hoeller, B. Sundaralingam, J. Tremblay, and S. Birchfield, Joint space control via deep reinforcement learning, in *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pp. 3619–3626, 2021
12. 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
13. 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, *IEEE Intl. Conf. on Robotics and Automation*, 2019, **Finalist for Best Paper in Robot Manipulation Award**
14. 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
15. 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
16. 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
17. 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
18. 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
19. B. Sundaralingam and T. Hermans, Relaxed-rigidity constraints: In-grasp manipulation using purely kinematic trajectory optimization, *Robotics: Science and Systems (RSS)*, 2017

Journal Articles

1. K. Van Wyk, M. Xie, A. Li, M. A. Rana, B. Babich, B. Peele, Q. Wan, I. Akinola, B. Sundaralingam, D. Fox, B. Boots, and N. D. Ratliff, Geometric fabrics: Generalizing classical mechanics to capture the physics of behavior, *IEEE Robotics and Automation Letters*, vol. 7, no. 2, pp. 3202–3209, 2022, **Best Paper Award RA-L 2022**
2. I. Huang, Y. Narang, C. Eppner, B. Sundaralingam, M. Macklin, R. Bajcsy, T. Hermans, and D. Fox, Defgraspsim: Physics-based simulation of grasp outcomes for 3d deformable objects, *IEEE Robotics and Automation Letters*, pp. 1–1, 2022
3. A. Bobu, C. Paxton, W. Yang, B. Sundaralingam, Y.-W. Chao, M. Cakmak, and D. Fox, Learning perceptual concepts by bootstrapping from human queries, *IEEE Robotics and Automation Letters*, 2022
4. Y. S. Narang, B. Sundaralingam, K. V. Wyk, A. Mousavian, and D. Fox, Interpreting and predicting tactile signals for the syntouch biotac, *The International Journal of Robotics Research*, vol. 40, no. 12-14, pp. 1467–1487, 2021
5. B. Sundaralingam and T. Hermans, In-hand object-dynamics inference using tactile fingertips, *IEEE Transactions on Robotics*, 2021
6. K. Aliaj, G. M. Feeney, B. Sundaralingam, T. Hermans, K. B. Foreman, K. N. Bachus, and H. B. Henninger, Replicating dynamic humerus motion using an industrial robot, *PLOS ONE*, vol. 15, pp. 1–23, 11 2020
7. 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
8. 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
9. B. Sundaralingam and T. Hermans, Relaxed-rigidity constraints: kinematic trajectory optimization and collision avoidance for in-grasp manipulation, *Autonomous Robots*, 2019

Preprints

1. B. Sundaralingam, S. K. S. Hari, A. Fishman, C. Garrett, K. V. Wyk, V. Blukis, A. Millane, H. Oleynikova, A. Handa, F. Ramos, N. Ratliff, and D. Fox, curobo: Parallelized collision-free minimum-jerk robot motion generation, 2023
2. J. Tremblay, B. Wen, V. Blukis, B. Sundaralingam, S. Tyree, and S. Birchfield, Diff-dope: Differentiable deep object pose estimation, *arXiv preprint arXiv:2310.00463*, 2023
3. C. Chamzas, C. Garrett, B. Sundaralingam, L. E. Kavraki, and D. Fox, Meta-policy learning over plan ensembles for robust articulated object manipulation, *arXiv preprint arXiv:2307.04040*, 2023
4. Y.-C. Chen, A. Murali, B. Sundaralingam, W. Yang, A. Garg, and D. Fox, Neural motion fields: Encoding grasp trajectories as implicit value functions, *arXiv preprint arXiv:2206.14854*, 2022

Patents

1. B. Sundaralingam, S. K. S. Hari, A. H. Fishman, C. R. Garrett, A. J. Millane, E. Oleynikova, A. Handa, F. T. Ramos, N. D. Ratliff, K. Van Wyk, *et al.*, Collision-free motion generation, Apr. 25 2024. US Patent App. 18/200,347
2. A. Handa, A. D. Allshire, D. Fox, J.-F. V. Lafleche, L. Jingzhou, V. Makoviichuk, Y. S. Narang, A. V. Petrenko, R. Singh, B. Sundaralingam, *et al.*, Training machine learning models using simulation for robotics systems and applications, Mar. 21 2024. US Patent App. 18/448,049
3. B. Sundaralingam, S. Birchfield, Z. Tang, J. Tremblay, S. Tyree, B. Wen, Y. Yuan, and C. Loop, Techniques for controlling robots within environments modeled based on images, Feb. 29 2024. US Patent App. 18/168,482
4. W. Yang, B. Sundaralingam, C. J. Paxton, M. Cakmak, Y.-W. Chao, D. Fox, and I. Akinola, Reactive interactions for robotic applications and other automated systems, Sept. 21 2023. US Patent App. 17/854,730
5. Y.-W. Chao, Y. Xiang, W. Yang, D. Fox, C. Paxton, B. Sundaralingam, and M. Cakmak, Simulating physical interactions for automated systems, Sept. 21 2023. US Patent App. 18/148,548
6. B. Sundaralingam, P. Sharma, C. J. Paxton, V. Blukis, T. Hermans, and D. Fox, Interactive cost corrections with natural language feedback, Aug. 31 2023. US Patent App. 18/055,569
7. A. Murali, B. Sundaralingam, C. Yun-Chun, D. Fox, and G. Animesh, Techniques for robot control using neural implicit value functions, Aug. 17 2023. US Patent App. 17/856,699
8. A. Bobu, B. Sundaralingam, C. J. Paxton, M. Cakmak, W. Yang, Y.-W. Chao, and D. Fox, Concept training technique for machine learning, May 11 2023. US Patent App. 17/982,401
9. I. Huang, Y. S. Narang, C. Eppner, B. Sundaralingam, M. Macklin, T. R. Hermans, and D. Fox, Method for assessing the quality of a robotic grasp on 3d deformable objects, 2022. US Patent App. 17/207,200
10. Y. S. Narang, B. Sundaralingam, K. Van Wyk, A. Mousavian, M. Macklin, and D. Fox, Robotic tactile sensing, 2022. US Patent App. 17/213,062
11. V. C. V. Kumar, D. Hoeller, B. Sundaralingam, J. Tremblay, and S. T. Birchfield, Transformation of joint space coordinates using machine learning, May 5 2022. US Patent App. 17/176,672
12. S. Birchfield, B. Boots, D. Fox, A. Handa, N. Ratliff, B. Sundaralingam, and A. Lambert, Force estimation using deep learning, 2020. US Patent App. 16/358,485

Honors & Awards

- Best Paper award at RA-L 2022.
- Selected for Oral presentation at CoRL 2021.
- Finalist for Best Manipulation Paper award at ICRA 2019.

Invited Talks

1. University of Washington 2024 CSE 571: AI-Robotics
2. NVIDIA GTC 2024
3. University of Utah Robotics Seminar 2019
4. Utah Deep learning meetup 2019
5. Benchmarking Manipulation workshop at ICRA 2019

Academic Service

Associate Editor

1. IEEE Robotics & Automation Letters 2024
2. IEEE International Conference on Robotics and Automation 2023
3. IEEE International Conference on Robotics and Automation 2022
4. IEEE International Conference on Robotics and Automation 2021

Reviewer

1. IEEE International Conference on Robotics and Automation [2017, 2019, 2020, 2021,2022, 2023]
2. IEEE/RSJ International Conference on Intelligent Robots and Systems [2019, 2020, 2021]
3. IEEE-RAS International Conference on Humanoid Robots [2017]
4. International Symposium on Robotics Research [2019]
5. International Conference on Learning Representations [2021]
6. Neural Information Processing Systems (Neurips) [2021]
7. Conference on Robot Learning [2018, 2020, 2022]
8. Elsevier Mechanisms and Machine Theory
9. IEEE Robotics and Automation Letters
10. IEEE Transactions on Robotics