# Ramkumar Natarajan

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## Education

**Carnegie Mellon University** — Pittsburgh, PA
*PhD in Robotics* — *Aug 2018 – Ongoing*

**Worcester Polytechnic Institute** — Worcester, MA
*MS in Robotics (Ranked 1st in class)* — *Aug 2015 – June 2017*

**SASTRA Unviersity** — Thanjavur, India
*BS in Electrical Engineering* — *Aug 2011 – May 2015*

## Work Experience

**Graduate Research Assistant** — Aug 2018 – Present
*Search Based Planning Lab and Biorobotics Lab at The Robotics Institute, CMU* — *Pittsburgh, PA*

- PhD candidate developing motion planning algorithms for highly dynamic tasks

**Senior Robotics Researcher** — Jun 2017 – Aug 2018
*RobotWits LLC (Acquired by Waymo LLC)* — *Pittsburgh, PA*

- Designed and developed multiple components of the planning subsystem including low-level high-speed planning, high-level route planning, and reasoning under uncertainty for autonomous driving
- Designed the fail-operational architecture for redundancy in the planning subsystem of self-driving vehicles

**Robotics Engineer** — May 2016 – May 2017
*Bossanova Robotics* — *Pittsburgh, PA*

- Extended Viola Jones rapid object detection algorithm to multi-channel images (color, depth, and intensity)
- Incorporated graph reductionist and tree decomposition methods to parallelize filtering and smoothing for SLAM

## Internships

**Research Intern** — May 2021 – Aug 2021
*Near Earth Autonomy* — *Pittsburgh, PA*

- Planning under uncertainty for autonomous landing of an unmanned aerial vehicle on a naval destroyer

**Robotics Research Intern** — Jun 2019 – Jul 2021
*RobotWits LLC (Acquired by Waymo LLC)* — *Pittsburgh, PA*

- Optimization-based planning for autonomous vehicles in unstructured spaces

**Visiting Researcher** — Aug. 2014 – May 2015
*Indian Institute of Technology(IIT) Madras* — *Chennai, India*

- Real-time navigation for Pioneer P3-DX mobile robot using lifelong SLAM

## Publications

[1] Ramkumar Natarajan, Chaoqi Liu, Howie Choset, and Maxim Likhachev. **Implicit Graph Search for Planning on Graphs of Convex Sets**. *Under Review at Robotics: Science and Systems*, 2024.

[2] Ramkumar Natarajan, Shohin Mukherjee, Howie Choset, and Maxim Likhachev. **PINSAT: Parallelized Interleaving of Graph Search and Trajectory Optimization for Kinodynamic Motion Planning**. *arXiv preprint arXiv:2401.08948*, 2024.

[3] Ramkumar Natarajan, Garrison L. H. Johnston, Nabil Simaan, Maxim Likhachev, and Howie Choset. **Long Horizon Planning through Contact using Discrete Search and Continuous Optimization**. *Under Review at IEEE Transactions on Robotics.*

[4] Ramkumar Natarajan*, Hanlan Yang*, Qintong Xie, Yash Oza, Manash Pratim Das, Fahad Islam, Muhammad Suhail Saleem, Howie Choset, and Maxim Likhachev. **Preprocessing-based Kinodynamic Motion Planning Framework for Intercepting Projectiles using a Robot Manipulator**. In *2024 IEEE International Conference on Robotics and Automation (ICRA)*. IEEE, 2024.

[5] Ramkumar Natarajan, Garrison LH Johnston, Nabil Simaan, Maxim Likhachev, and Howie Choset. **Torque-limited manipulation planning through contact by interleaving graph search and trajectory optimization**. In *2023 IEEE International Conference on Robotics and Automation (ICRA)*, pages 8148–8154. IEEE, 2023.

[6] Ramkumar Natarajan, Howie Choset, and Maxim Likhachev. **Interleaving graph search and trajectory optimization for aggressive quadrotor flight**. *IEEE Robotics and Automation Letters*, 6(3):5357–5364, 2021.

[7] Ramkumar Natarajan, Muhammad Saleem, Sandip Aine, Maxim Likhachev, and Howie Choset. **A-MHA*: anytime multi-heuristic A**. In *Proceedings of the International Symposium on Combinatorial Search*, volume 10, pages 192–193, 2019.

[8] Ramkumar Natarajan and Michael A Gennert. **Efficient factor graph fusion for multi-robot mapping and beyond**. In *2018 21st International Conference on Information Fusion (FUSION)*, pages 1137–1145. IEEE, 2018.

[9] Siddharthan Rajasekaran*, Ramkumar Natarajan*, and Jonathan D Taylor. **Towards planning and control of hybrid systems with limit cycle using lqr trees**. In *2017 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, pages 5196–5203. IEEE, 2017.

## Patents

[1] Jonathan Davis Taylor and Ramkumar Natarajan. **Color Haar Classifier for Retail Shelf Label Detection**. Google Patents, June 13 2019. US Patent App. 16/219,238.

## Technical Reports

[1] Sri Ramana Sekharan, Ramkumar Natarajan, and Siddharthan Rajasekaran. **Transfer from multiple linear predictive state representations (PSR)**. *arXiv preprint arXiv:1702.02184*, 2017.

## Thesis

[1] Ramkumar Natarajan. **Efficient Factor Graph Fusion for Multi-robot Mapping**, 2017.

## Technical Skills

**Languages**: C/C++, Python, Matlab, Julia, Verilog
**Developer Tools**: ROS, Eigen, Boost, PyTorch, OpenCV, Git, Docker, SolidWorks, Arduino

## Invited Talks

**Implicit Graph Search for Planning on Graphs of Convex Sets** Nov 2023
*Robot Locomotion Group, MIT* *Cambridge, MA*

**Use of Topology in Optimal Motion Planning** ICRA 2019
*Workshop on Topological Methods in Motion Planning* *Montreal, Canada*

## Teaching

**16-745 Optimal Control and Reinforcement Learning** Spring 2021
*Teaching Assistant for course taught by Chris Atkeson* *The Robotics Institute, CMU*

**16-782 Planning and Decision-making in Robotics** Fall 2020
*Teaching Assistant for course taught by Maxim Likhachev* *The Robotics Institute, CMU*

**ECE 3829: Advanced Digital System Design using FPGAs** Spring 2016
*Teaching Assistant* *WPI*

## Scholastic Achievements

**Ranked $1^{st}$ in the MS in Robotics Engineering in a class of 48 students.** 2017
*Worcester Polytechnic Institute (WPI)* *Worcester, MA*

**Junior Research Fellowship** 2013
*Center for Artificial Intelligence & Robotics - Defense Research and Development Organization (CAIR - DRDO)* *India*

## References

**Prof. Maxim Likhachev** Professor, The Robotics Institute, CMU
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**Prof. Howie Choset** Professor, The Robotics Institute, CMU
*choset@cs.cmu.edu*