

Senthil Hariharan Arul

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Education

University of Maryland

PH.D. IN ELECTRICAL AND COMPUTER ENGINEERING

College Park, USA

Aug 2019 - Current

- **Advisor:** Prof. Dinesh Manocha
- Developing algorithms for cooperative multi-robot navigation and collision avoidance

National Institute of Technology

BACHELOR OF TECHNOLOGY IN INSTRUMENTATION AND CONTROL

Tiruchirappalli, India

Aug. 2013 - May 2017

- **Advisor:** Dr. V. Sridevi
- Project: Automatic system for removal of artifacts from EEG signals using Independent Component Analysis (ICA) and Hurst Exponent

Experience

University of Maryland

RESEARCH ASSISTANT

College Park, USA

Spring 2020 - Current

- **Project:** Multi-agent collision avoidance and motion planning
- **Advisor:** Prof. Dinesh Manocha
- Research explores the area of decentralized multi-agent collision avoidance and navigation methods for quadrotors and ground vehicles.
- Currently exploring Multi-Agent Reinforcement Learning (MARL) methods for cooperative collision avoidance and navigation in dense scenarios by learning selective inter-agent communication for navigation.

Amazon Lab126

APPLIED SCIENTIST INTERN

Sunnyvale, CA, USA

Summer 2023

- **Project:** Zero-Shot Object Goal Navigation
- Developed an hybrid-approach with foundation models and conventional model-based approach for object goal navigation of ground robots.

Amazon Lab126

APPLIED SCIENTIST INTERN

Sunnyvale, CA, USA

Summer 2022

- **Project:** Reducing Robot Freezing Behavior
- **Mentor:** Jong Jin Park
- Explored cost formulations to reduce robot freezing problem in static environments for a Model Predictive Control (MPC) based trajectory planner.
- The cost formulation was shown to satisfy stability and safety definitions typical with control barrier functions.
- Currently pursuing the research direction as a part of *Amazon Lab126 Seed Grant 2022-23* ([link](#)) under the advise of Jong Jin Park and Prof. Dinesh Manocha.

University of Maryland

TEACHING ASSISTANT, ENEE 460: CONTROL THEORY (INSTRUCTOR: PROF. RICHARD LA)

College Park, USA

Fall 2019

- Conducted discussion sessions, office hours, and graded assignments for the undergraduate course on control theory

University of Maryland

SUMMER RESEARCH INTERN

College Park, USA

May 2018 - August 2018

- **Project:** DARPA OFFSET
- **Advisor:** Prof. Dinesh Manocha
- Involved in the development and implementation of LSwarm, an algorithm for efficient collision avoidance under strict coverage constraints enforced by Ground Sampling Distance (GSD).
- Assisted in the development of a ROS collision avoidance package, which was released and presented at ROSCon 2019 ([link](#)).

- **Project:** Software Development for Autonomous Collaborative Robotic Arm
- **Advisor:** Prof. Gary Bone
- Successfully implemented a model based collision avoidance for a CRS F3 robotic arm using point cloud data from Microsoft Kinect.
- Implemented a vision-based modeling and grasping software to autonomously identify the object in the workspace, model the object in 3D, and compute the end-effector orientation for an effective grasp.

Skills

Languages C++, C, Python, MATLAB

Libraries/Framework ROS, TensorFlow, OpenCV, Point Cloud Library (PCL)

Publication

Journal Articles

- 1 Zinage, V., **Arul, S. H.**, Manocha, D., & Ghosh, S. (2023). 3d-online generalized sensed shape expansion: A probabilistically complete motion planner in obstacle-cluttered unknown environments. *IEEE Robotics and Automation Letters*, 8(6), 3334–3341. [doi:10.1109/LRA.2023.3263376](https://doi.org/10.1109/LRA.2023.3263376)
- 2 **Arul, S. H.**, & Manocha, D. (2021a). Swarmcco: Probabilistic reactive collision avoidance for quadrotor swarms under uncertainty. *IEEE Robotics and Automation Letters*, 1–1. [doi:10.1109/LRA.2021.3061975](https://doi.org/10.1109/LRA.2021.3061975)
- 3 **Arul, S. H.**, & Manocha, D. (2020). Dcad: Decentralized collision avoidance with dynamics constraints for agile quadrotor swarms. *IEEE Robotics and Automation Letters*, 5(2), 1191–1198. [doi:10.1109/LRA.2020.2967281](https://doi.org/10.1109/LRA.2020.2967281)
- 4 **Arul, S. H.**, Sathyamoorthy, A. J., Patel, S., Otte, M., Xu, H., Lin, M. C., & Manocha, D. (2019). Lswarm: Efficient collision avoidance for large swarms with coverage constraints in complex urban scenes. *IEEE Robotics and Automation Letters*, 4(4), 3940–3947. [doi:10.1109/LRA.2019.2929981](https://doi.org/10.1109/LRA.2019.2929981)

Conference Proceedings

- 1 **Arul, S. H.**, Park, J. J., & Manocha, D. (2023). Ds-mpepc: Safe and deadlock-avoiding robot navigation in cluttered dynamic scenes. In *2023 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*.
- 2 Agrawal, A., **Arul, S. H.**, Bedi, A. S., & Manocha, D. (2022). Dc-mrta: Decentralized multi-robot task allocation and navigation in complex environments. In *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 11711–11718). [doi:10.1109/IROS47612.2022.9981353](https://doi.org/10.1109/IROS47612.2022.9981353)
- 3 **Arul, S. H.**, & Manocha, D. (2022). Cglr: Dense multi-agent navigation using voronoi cells and congestion metric-based replanning. In *2022 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 7213–7220). [doi:10.1109/IROS47612.2022.9982110](https://doi.org/10.1109/IROS47612.2022.9982110)
- 4 **Arul, S. H.**, & Manocha, D. (2021b). V-rvo: Decentralized multi-agent collision avoidance using voronoi diagrams and reciprocal velocity obstacles. In *2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)* (pp. 8097–8104). [doi:10.1109/IROS51168.2021.9636618](https://doi.org/10.1109/IROS51168.2021.9636618)
- 5 Patel, S., **Arul, S. H.**, Dhulipala, P., Lin, M. C., Manocha, D., Xu, H., & Otte, M. (2021). Multi-agent ergodic coverage in urban environments. In *2021 IEEE International Conference on Robotics and Automation*.

ArXiv

- 1 **Arul, S. H.**, Bedi, A. S., & Manocha, D. (2022). Dmca: Dense multi-agent navigation using attention and communication. arXiv: 2209.06415 [cs.RO]