Senthil Hariharan **Arul**

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Education

University of Maryland
College Park, USA

Ph.D. in Electrical and Computer Engineering — *Aug 2019 - Current*

- **Advisor**: Prof. Dinesh Manocha
- Designing decentralized algorithms for cooperative navigation and collision avoidance across various scenarios involving multiple robots and social navigation. Conducting research to explore applications of geometric principles, reinforcement learning techniques, and control theory in this domain.

National Institute of Technology
Tiruchirappalli, India

Bachelor of Technology in Instrumentation and Control — *Aug. 2013 - May 2017*

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

Experience

University of Maryland
College Park, USA

Research Assistant — *Spring 2020 - Current*

- **Project**: Multi-agent collision avoidance and motion planning
- **Advisor**: Prof. Dinesh Manocha
- Conducting research in the field of decentralized multi-agent collision avoidance and navigation methods, with a focus on quadrotors and ground vehicles.
- Actively investigating Multi-Agent Reinforcement Learning (MARL) methods to enhance cooperative navigation in dense scenarios. Specifically, leveraging selective inter-agent communication for navigation improvement.

Amazon Lab126
Sunnyvale, CA, USA

Applied Scientist Intern — *Summer 2023*

- **Project:** Zero-Shot Object Goal Navigation
- Developed a hybrid approach integrating foundational models (esp. Visual Language Models (VLM)) with conventional model-based methods to achieve autonomous object goal navigation for ground robots.

Amazon Lab126
Sunnyvale, CA, USA

Applied Scientist Intern — *Summer 2022*

- **Project:** Reducing Robot Freezing Behavior
- **Mentor:** Jong Jin Park
- Explored cost formulations to mitigate the robot freezing issue for a Model Predictive Control (MPC) based trajectory planner, enhancing navigation behavior in probabilistic scenarios.
- Demonstrated that the developed cost formulation complies with stability and safety definitions commonly associated with control barrier functions.
- Continued research as part of the *Amazon Lab126 Seed Grant 2022-23 (link).*

University of Maryland
College Park, USA

Teaching Assistant, ENEE 460: Control Theory (Instructor: Prof. Richard La) — *Fall 2019*

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

University of Maryland
College Park, USA

Summer Research Intern — *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, released and presented at ROSCon 2019 (link).

McMaster University *Hamilton, Ontario, Canada*

Summer Research Intern, RMAL (Mitacs Globalink Program) *May 2016 - August 2016*

- **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.
- Amongst $\approx$ 120 undergraduate students selected across India to pursue funded summer research through MITACS.

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
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
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
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

Conference Proceedings

1. **Arul, S. H.**, Park, J. J., & Manocha, D. (2024). Unconstrained model predictive control for robot navigation under uncertainty. In *Accepted at 2024 ieee international conference on robotics and automation (icra)*.
2. **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)*.
3. 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
4. **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
5. **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
6. 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*.

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