

Sanjiban Choudhury

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Current Position

2018–Present **Postdoctoral Fellow**, *University of Washington*, CSE Department.

Education

2013–2018 **PhD, Robotics**, *Carnegie Mellon University*, USA.

Advisor: Prof. Sebastian Scherer

Thesis: *Adaptive Motion Planning*

2011–2013 **MS, Robotics**, *Carnegie Mellon University*, USA.

Advisor: Prof. Sanjiv Singh & Prof. Sebastian Scherer

Thesis: *Autonomous Emergency Landing of a Helicopter: Motion Planning with Hard Time Constraints*

GPA: 4.06/4.0

2006–2011 **B.Tech, M.Tech, Electrical Engineering**, *Indian Institute of Technology Kharagpur*, India.

Advisor: Prof. Jayanta Mukherjee & Prof. Alok Deb

Thesis: *Application of Reinforcement Learning in Robot Soccer*

GPA: 9.30/10.0

Research Experience

2016 **Research Intern**, *Microsoft Research*, USA.

Worked with Debadeepta Dey, Ashish Kapoor and Gireeja Ranade on sequential decision making via imitation learning. Our work was published at ICRA 2017, RSS 2017 and invited to IJRR.

2011–2017 **Research Engineer**, *Carnegie Mellon University*, USA.

Worked at the AirLab (<http://theairlab.org/>) developing the motion planning stack for various robots ranging from full-scale helicopters to small quadrotors. I also had auxiliary roles such as writing sensor drivers, controllers and maintaining lab repositories.

2009–2011 **Research Engineer**, *Indian Institute of Technology Kharagpur*, India.

Started the Kharagpur Robosoccer Group (<http://krssg.in/>) under the supervision of Prof. Jayanta Mukherjee and Prof. Sudeshna Sarkar. Worked with a team of undergraduates on both hardware and software for a team of robots for RoboCup SSL and FIRA Mirosot.

2009 **Summer Intern**, *Carnegie Mellon University*, USA.

Worked with Prof. Sanjiv Singh on coverage path planning algorithms for agricultural robots.

2008 **Summer Intern**, *University of Thessaly*, Greece.

Worked with Prof. Simon Blackmore on localization and mapping for agricultural robots.

Awards

2017 **Finalist for the Collier Trophy**.

The AACUS (Autonomous Aerial Cargo/Utility System) project, which was the focus of my thesis research, is a finalist for the 2017 Robert J. Collier Trophy awarded "for the greatest achievement in aeronautics or astronautics in America". Previous winners include Apollo 11, Boeing 747.

- 2014 **Best Paper for Unmanned VTOL Aircraft & Rotorcraft track, AHS.**
“The Planner Ensemble and Trajectory Executive: A High Performance Motion Planning System with Guaranteed Safety”
- 2013 **Siebel Scholar.**
For academic excellence and demonstrated leadership.
- 2006 **National Tata Millenium Scholarship.**
For academic excellence.
- 2005 **Finalist for Indian Physics Olympiad.**
Awarded to the top 1% of participants

Robots

- 2013-2017 **Full-scale Helicopter, Planning.**
Developed the motion planning software pipeline for a full-scale autonomous helicopter for ONR’s AACUS project. The robot can fly up to 60m/s and sense up to 1200m. The software was evaluated on multiple platforms: Boeing’s Unmanned Little Bird and Bell 206 Jetranger.
- 2017 **Large Hexarotor, Planning.**
Developed the motion planning software for a hexarotor platform belonging to Near Earth Autonomy. The platform is a DJI-M600 that flies up to 15m/s. It has two VLP-16 sensors with 100m range.
- 2017 **Small Quadrotor, Planning.**
Developed the motion planning software for a quadrotor platform assembled by AirLab. The platform is a DJI-M100 that flies up to 5m/s. It has a Hokuyo laser with 18m range.
- 2015 **PixHawk Trajectory Tracker, Control.**
Implemented a spline trajectory tracker for a PX4 unit using a differentially flat controller. The code was tested on a custom quadrotor platform flying indoors.
- 2012-2013 **Large Octorotor, Planning.**
Developed the motion planning software for a custom octorotor platform tasked with autonomously exploring river banks. The robot can fly up to 3m/s and sense upto 18m.
- 2012 **Shipdeck Tracking Sensor, Hardware, Perception.**
Wrote software drivers for a sensor suite that is mounted on a full-scale helicopter and is capable of actively tracking a landing site on a shipdeck. The sensor suite has 3 cameras, SICK LDMRS laser GPS INS and time server board. I also worked on the registration and particle filter pipeline.
- 2010-2011 **FIRA Mirobot (5) League Robotosoccer Team, Hardware, Perception, Control, Planning.**
Led a team of undergraduates to compete as the first Indian Mirobot team in FIRA against 10 teams from around the world. Worked on all aspects of the project: robot hardware, vision pipeline, feedback control, motion planning and high level multi-agent strategies.
- 2009-2010 **RoboCup SSL Robotosoccer Team, Hardware, Perception, Control, Planning.**
Member of a team of undergraduates to compete in the Indian leg of Robocup SSL. Designed hardware and control for an omni-directional robot, vision pipeline and motion planning.

Technical Experience

- languages C, C++, MATLAB, Python, Java, C#
- libraries and tools ROS, PCL, OpenCV, OMPL, QT, TensorFlow, Gym, Meshlab, SolidWorks, Microsoft Robotics Studio, Simulink

Teaching

- 2015 **Statistical Techniques in Robotics, Carnegie Mellon University, USA.**
Teaching assistant for Prof. Kris Kitani and Prof. Michael Kaess

2010 **Signals and Systems**, *Indian Institute of Technology Kharagpur*, India.
Laboratory assistant for Prof. Dheeman Chatterjee

Mentoring

PhD students Rogerio Bonatti (current)

M.S. students Vishal Dugar (current)

Interns Anirudh Vemula (PhD, CMU), Mohak Bhardwaj (PhD), Jit Roy Choudhury (CEO, Auro)

Service

Workshop *Machine Learning in Robot Motion Planning*, IROS 2018 (submitted)

Organizer *Complex Collaborative Systems: Closing the Loop, Learning & Self-Confidence*, IROS 2017

Reviewer IJRR, IEEE-TRO, IEEE RA-L, JRAS, JFR, RSS, ICRA, IROS, ICUAS

Invited Talks

2018 **Data-driven Planning via Imitation Learning**, *ICRA*.

Workshop on Informative Path Planning and Adaptive Sampling

2017 **Adaptive Motion Planning**, *IROS*.

Workshop on Complex Collaborative Systems

2016 **Theoretical Planning Limits using Markov Chains**, *Microsoft Research*.

Adaptive Systems and Interaction (ASI) group

Outreach

Hobby Governor of the Technology Robotix Society, IIT Kharagpur. I was the coordinator for ROBOTIX Robotics (<https://2018.robotix.in/>), a major inter-collegiate event. We also conducted free hands-on workshops across multiple cities, created and managed online tutorials and raised funding.

Robotsoccer Founding member of the Kharagpur RoboSoccer Students Group (<http://krssg.in/>). I led the Community first Indian team to participate in the international FIRA Mirost league. We also organized the first Indian leg of the RoboCup league. We raised funding for lab equipments, organized hands-on workshops to recruit undergraduates and promoted the event nationwide to encourage competition.

Lab Tours Demos and tours of the AirLab and Field Robotics Centre to the general public

Community Volunteered at Child Relief and You (CRY) in Kolkata to teach kids from ages 9-13

Outreach Volunteered at Rural Development Centre in Kharagpur

Culture Selected as a member of the JENESYS exchange program. We traveled to Japan and participated Exchange in historical, cultural and educational programs. I was elected to give a keynote speech on behalf of the Nagasaki group at the Tokyo embassy.

Publications

Thesis

[1] Sanjiban Choudhury. "Adaptive Motion Planning". Carnegie Mellon University, 2018.

Journals

[1] Stephen Nuske, Sanjiban Choudhury, Sezal Jain, Andrew Chambers, Luke Yoder, Sebastian Scherer, Lyle Chamberlain, Hugh Cover, and Sanjiv Singh. "Autonomous Exploration and Motion Planning for an Unmanned Aerial Vehicle Navigating Rivers". In: *Journal of Field Robotics* 32.8 (2015), pp. 1141–1162.

- [2] Shushman Choudhury, Oren Salzman, Sanjiban Choudhury, Christopher M Dellin, and Siddhartha S Srinivasa. "Anytime Motion Planning on Large Dense Roadmaps with Expensive Edge Evaluations". In: *International Journal of Robotics Research* (2018 (submitted)).

Conferences

- [1] Mohak Bhardwaj, Sanjiban Choudhury, and Sebastian Scherer. "Learning Heuristic Search via Imitation". In: *Proceedings of the 1st Annual Conference on Robot Learning*. 2017.
- [2] Sanjiban Choudhury, Shervin Javdani, Siddhartha Srinivasa, and Sebastian Scherer. "Near-Optimal Edge Evaluation in Explicit Generalized Binomial Graphs". In: *31st Conference on Neural Information Processing Systems*. 2017.
- [3] Sanjiban Choudhury, Ashish Kapoor, Gireeja Ranade, and Debadeepta Dey. "Learning to Gather Information via Imitation". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2017.
- [4] Sanjiban Choudhury, Ashish Kapoor, Gireeja Ranade, Sebastian Scherer, and Debadeepta Dey. "Adaptive Information Gathering via Imitation Learning". In: *Proceedings of Robotics: Science and Systems*. 2017.
- [5] Shushman Choudhury, Oren Salzman, Sanjiban Choudhury, and Siddhartha Srinivasa. "Densification Strategies for Anytime Motion Planning over Large Dense Roadmaps". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2017.
- [6] Vishal Dugar, Sanjiban Choudhury, and Sebastian Scherer. "A KITE in the Wind: Smooth Trajectory Optimization in a Moving Reference Frame". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2017.
- [7] Vishal Dugar, Sanjiban Choudhury, and Sebastian Scherer. "Smooth Trajectory Optimization in Wind: First Results on a Full-Scale Helicopter". In: *Proceedings American Helicopter Society 73rd Annual Forum*. 2017.
- [8] Sanjiban Choudhury, Jonathan D. Gammell, Timothy D. Barfoot, Siddhartha Srinivasa, and Sebastian Scherer. "Regionally Accelerated Batch Informed Trees (RABIT*): A Framework to Integrate Local Information into Optimal Path Planning". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2016.
- [9] Guilherme Augusto Silva Pereira, Sanjiban Choudhury, and Sebastian Scherer. "A Framework for Optimal Repairing of Vector Field-based Motion Plans". In: *Proceedings of the IEEE International Conference of Unmanned Aircraft Systems*. 2016.
- [10] Guilherme Augusto Silva Pereira, Sanjiban Choudhury, and Sebastian Scherer. "Nonholonomic motion planning in partially unknown environments using vector fields and optimal planners". In: *Proceedings Congresso Brasileiro de Automatica (CBA)*. 2016.
- [11] Abhijeet Tallavajhula, Sanjiban Choudhury, Sebastian Scherer, and Alonzo Kelly. "List Prediction Applied To Motion Planning". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2016.
- [12] Sankalp Arora, Sanjiban Choudhury, Daniel Althoff, and Sebastian Scherer. "Emergency Maneuver Library – Ensuring Safe Navigation in Partially Known Environments". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2015.
- [13] Sanjiban Choudhury, Sankalp Arora, and Sebastian Scherer. "The Planner Ensemble: Motion Planning by Executing Diverse Algorithms". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2015.

- [14] Sanjiban Choudhury and Sebastian Scherer. "The Dynamics Projection Filter (DPF) – Real-Time Nonlinear Trajectory Optimization Using Projection Operators". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2015.
- [15] Sanjiban Choudhury, Sebastian Scherer, and J. Andrew (Drew) Bagnell. "Theoretical Limits of Speed and Resolution for Kinodynamic Planning in a Poisson Forest". In: *Proceedings of Robotics: Science and Systems*. 2015.
- [16] J. Paduano, J. Wissler, M. Piedmonte G. Drozeski, N. Dadkhah, J. Francis, C. Shortlidge, J. Bold, F. Langford, M. Chaoui, C. J. Liu, E. Foster, S. Singh, L. Chamberlain, B. Hamner, H. Cover, A. Stambler, A. Singh, S. Nalbone, M. Bergerman, S. Scherer, S. Choudhury, S. Maeta, S. Arora, D. Althoff, D. Maturana, D. Limbaugh, J. Bona, D. Barnhard, D. Chessar, D. Mindell, C. Dominguez, B. Moon, R. Strouse, L. Papautsky, D. Cerchie, B. Chu, J. Graham, C. Cameron, M. Hardesty, and R. Hehr. "TALOS: An Unmanned Cargo Delivery System for Rotorcraft Landing to Unprepared Sites". In: *Proceedings American Helicopter Society 71st Annual Forum*. 2015.
- [17] Sankalp Arora, Sanjiban Choudhury, Sebastian Scherer, and Daniel Althoff. "A Principled Approach to Enable Safe and High Performance Maneuvers for Autonomous Rotorcraft". In: *Proceedings American Helicopter Society 70th Annual Forum*. 2014.
- [18] Sanjiban Choudhury, Sankalp Arora, and Sebastian Scherer. "The Planner Ensemble and Trajectory Executive: A High Performance Motion Planning System with Guaranteed Safety". In: *Proceedings American Helicopter Society 70th Annual Forum*. 2014.
- [19] Sanjiban Choudhury, Sebastian Scherer, and Sanjiv Singh. "Autonomous Emergency Landing of a Helicopter: Motion Planning with Hard Time Constraints". In: *Proceedings American Helicopter Society 69th Annual Forum*. 2013.
- [20] Sanjiban Choudhury, Sebastian Scherer, and Sanjiv Singh. "RRT*-AR: Sampling-based Alternate Routes Planning with Applications to Autonomous Emergency Landing of a Helicopter". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2013.
- [21] Hugh Cover, Sanjiban Choudhury, Sebastian Scherer, and Sanjiv Singh. "Sparse Tangential Network (SPARTAN): Motion Planning for Micro Aerial Vehicles". In: *Proceedings IEEE International Conference on Robotics & Automation*. 2013.

Workshops and Tech Reports

- [1] Sanjiban Choudhury and Siddhartha S Srinivasa. "Bayesian Active Edge Evaluation on Expensive Graphs". In: *Blue Sky Track International Symposium on Robotics Research*. 2017.
- [2] Sanjiban Choudhury, Siddhartha Srinivasa, and Sebastian Scherer. "A Bayesian Active Learning Approach to Adaptive Motion Planning". In: *Workshop on Acting and Interacting in the Real World, NIPS*. 2017.
- [3] Sanjiban Choudhury, Siddhartha Srinivasa, and Sebastian Scherer. "Bayesian Active Edge Evaluation on Expensive Graphs". In: *arXiv preprint arXiv:1711.07329* (2017).
- [4] Sanjiban Choudhury and Sebastian Scherer. *Constrained CHOMP using Dual Projected Newton Method*. Tech. rep. CMU-RI-TR-16-17. Carnegie Mellon University, 2016.
- [5] Guilherme Augusto Silva Pereira, Sanjiban Choudhury, and Sebastian Scherer. *Kinodynamic Motion Planning on Vector Fields using RRT**. Tech. rep. CMU-RI-TR-16-35. Carnegie Mellon University, 2016.

- [6] Sanjiban Choudhury. *Lower and Upper Bounds for the Survival of Infinite Absorbing Markov Chains*. Tech. rep. CMU-RI-TR-05-04. Carnegie Mellon University, 2015.
- [7] Abhijeet Tallavajhula and Sanjiban Choudhury. *List prediction for motion planning: Case studies*. Tech. rep. CMU-RI-TR-15-25. Carnegie Mellon University, 2015.
- [8] Anirudh Vemula, Sanjiban Choudhury, and Sebastian Scherer. *Learning Motion Planning Assumptions*. Tech. rep. CMU-RI-TR-14-14. Carnegie Mellon University, 2014.
- [9] Sanjiban Choudhury, Sebastian Scherer, and Sanjiv Singh. *Realtime Alternate Eoutes Planning: The RRT*-AR Algorithm*. Tech. rep. CMU-RI-TR-12-27. Carnegie Mellon University, 2012.