Saumya Saxena

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Education

Carnegie Mellon University, Pittsburgh — Pittsburgh, PA
Ph.D. student, Robotics Institute, School of Computer Science — *Aug 2019 – May 2025 (expected)*

Carnegie Mellon University, Pittsburgh — Pittsburgh, PA
Master of Science - Research in Mechanical Engineering; QPA: 4.0/4.0 — *Aug 2017 – May 2019*

Indian Institute of Technology (IIT) Kanpur — Kanpur, India
B.Tech. M.Tech. Dual Degree B. Tech. CPI: 8.0/10.0 M. Tech. CPI: 9.3/10.0 — *2010 – 2015*

Research Statement

*My research lies at the intersection of **modern control theory, robot learning** and **multimodal foundation models for robotics**, with a focus on developing generalist robotic agents capable of performing complex long-horizon dynamic and interactive tasks in unstructured environments. I am particularly interested in leveraging multimodal foundation models for **semantic scene understanding** to perform embodied tasks in novel environments, as well as to ensure adherence to **semantic safety** constraints in dynamic and interactive settings. My long-term goal is to build general-purpose robots capable of lifelong and reliable operations in open-world settings enabling collaboration with humans in assistive and caregiving roles.*
Keywords: robot learning, foundation models for robotics, semantic safety, dynamic manipulation, semantic navigation, embodied AI, scene graphs, switching systems, graph neural networks, differentiable control.

Publications

- **S. Saxena**, A. Bajcsy and O. Kroemer. Safe Manipulation via Task-Relevant Reach-Avoid Reinforcement Learning. **2025**. (Under review) [Paper]
- **S. Saxena***, B. Buchanan*, C. Paxton, et al. **GraphEQA**: Using 3D Semantic Scene Graphs for Real-time Embodied Question Answering. arXiv, **2024**. (Under review) [Website]
- **S. Saxena***, M. Sharma* and O. Kroemer. **MResT**: Multi-Resolution Sensing for Real-Time Control with Vision-Language Models. Conference on Robot Learning (**CoRL**) **2023**. [Website]
- **S. Saxena**, and O. Kroemer. Dynamic Inference on Graphs using Structured Transition Models. *International Conference on Intelligent Robots and Systems* (**IROS**) **2022**. [Paper]
- J. Liang, M. Sharma, A. Lagrassa, S. Vats, **S. Saxena**, and O. Kroemer. Search-based task planning with learned skill effect models for lifelong robotic manipulation. *International Conference on Robotics and Automation* (**ICRA**) **2022**. [Paper]
- **S. Saxena**, A. LaGrassa, and O. Kroemer. Learning reactive and predictive differentiable controllers for switching linear dynamical models. *International Conference on Robotics and Automation* (**ICRA**) **2021**. [Paper]
- J. Liang, **S. Saxena**, and O. Kroemer. Learning Active Task-Oriented Exploration Policies for Bridging the Sim-to-Real Gap. *Robotics: Science and Systems* (**RSS**) **2020**. [Paper]
- N. Zevallos, A. Srivatsan Rangaprasad, H. Salman, L. Li, J. Qian, **S. Saxena**, M. Xu, K. Patath, and H. Choset. A real-time augmented reality surgical system for overlaying stiffness information. *Robotics: Science and Systems* (**RSS**) **2018**. [Paper]
- N. Zevallos, A. Srivatsan Rangaprasad, H. Salman, L. Li, J. Qian, **S. Saxena**, M. Xu, K. Patath, and H. Choset. A surgical system for automatic registration, stiffness mapping and dynamic image overlay. *International Symposium on Medical Robotics* (**ISMR**) **2018**. [Paper]

Master's Dissertation

Motion planning under uncertainty and sensing limitations using exploration versus exploitation. [Report]
Advised by Prof. H. Choset and Prof M. Travers, Robotics Institute, CMU — *Aug 2018 - May 2019*

- Developed a novel sampling-based planner (**Particle Filter based Affine Quadratic Tree: PF-AQT**) that explores the environment, and plans to reach a goal with minimal uncertainty.
- The output trajectory from PF-AQT was then used to initialize an optimization-based planner that finds a locally optimal trajectory that minimizes control effort and uncertainty.

Numerical investigation of Indian plucked musical instruments [Thesis]
Advised by Prof. Anurag Gupta, Dept. of Mechanical Engineering, IIT Kanpur, India — *May 2014 - July 2015*

- Developed a general numerical approach to model plucked instruments like tanpura which have a curved bridge.
- Captured model dynamics using a dissipative model, which allowed energy transfer from strings to resonator.
- Demonstrated the occurrence of precursor waves that are responsible for the characteristic buzzing sound.

Technical Skills

- **Languages**: Python, C/C++
- **Numerical Computation**: PyTorch, TensorFlow, Matlab, Ansys

Key Courses

- Statistical techniques for robotics
- Planning in Robotics
- Probabilistic Graphical Models
- Machine Learning
- Convex optimization
- Robot Design and Experimentation
- Underactuated robotics
- Computer Vision
- AI and ML for Engineering Design

Experience

Bosch Center for Artificial Intelligence Renningen, Germany
Research Intern *May 2023 - August 2023*

- Worked on vision-language navigation in unseen multi-room indoor environments using the RxR dataset.
- Developed a method that leverages a VLM-based planner to translate RxR instructions into low-level subtasks, which are then executed using a pretrained language-conditioned multi-task navigation policy.

General Electric Aviation India Technology Center, Bangalore, India
Edison Engineer, Combustor Design and Technology *July 2016 - July 2017*

- Worked on a high power **(70MW) aero-derivative gas turbine engine** (LM9000) for industrial applications.
- Achieved **low NOx (< 15 ppm)** and high-performance for the flexible-fuel combustor using CFD.

General Electric Aviation India Technology Center, Bangalore, India
Edison Engineer, High Pressure Compressor Design *July 2015 - July 2016*

- Worked on **GE9X**, the largest and most powerful commercial aircraft engine in the world, which will power Boeing777X.
- Designed critical 3D features of high pressure compressor like airfoils, lock slots and bolted joints.

Smart Materials, Structures and Systems Lab IIT Kanpur, India
Intern, advised by Prof. Bishakh Bhattacharya *May 2012 - July 2012*

- Designed a PID-based closed loop feedback controller in LABVIEW to actuate **shape memory alloy wires** that drive a 5-link mechanism for trajectory plotting using inverse kinematics.

Academic Projects

Contact detection and localization using particle filters for collaborative robots
Biorobotics lab, CMU *May 2018 - July 2018*

- Worked on a particle filter based approach to, in real time, estimate the contact location and force based on only joint position and torque readings.
- The estimated contact location and force converges to within 10% of the actual values in 0.3sec for a 6 DoF arm.

Inertial reorientation of a freely falling cat using non-holonomic motion planning [Report]
Robot Design and experimentation course project, CMU *Jan 2018 - May 2018*

- Worked in a team to **design, build, and control an inertial-reorienting robot**, mimicking the cat-righting reflex.
- Generated feed-forward trajectories in simulation for the motion plan of an underactuated system with non-holonomic constraints modelled as two rigid bodies connected by a universal joint.
- Successfully dropped the robot from a height of 1.65 m and attained full maneuver in 0.58 sec.

Coverage using graph-based planning for autonomous exploration of non-uniform environments [Report]
Planning and Decision-making in Robotics course project, CMU *Jan 2018 - May 2018*

- Developed a graph-based planning algorithm for coverage of a non-uniform information map which can be useful for mapping of dynamic environments and search and rescue operations.
- Developed an iterative planner with Multi-Goal A* in the loop which takes the robot to the nearest unexplored node with highest information gain till the entire map is sufficiently explored.
- Planner performs well for large graphs of size 50m$\times$50m with 10cm discretization and plans for the full map in 2 mins.

Surgical system for automatic registration, stiffness mapping and dynamic image overlay Paper
Biorobotics lab, CMU *Aug 2017 - Oct 2017*

- Worked in a team to develop a surgical system using the **da Vinci research kit (dVRK)** that is capable of autonomously searching for tumors and dynamically displaying the tumor location using **augmented reality**.
- Worked on state-of-the-art methods in **registration, force sensing and tumor localization** and incorporated them in a unified surgical system.

Regenerative braking system for bicycles
*Awarded the Jayesh Memorial **award for Best Undergraduate Project** in ME department, IIT Kanpur* *Aug 2013 - Nov 2013*

- Built a system to store the kinetic energy otherwise lost during braking using a spiral torsional spring.
- Stored energy assisted in acceleration from halt. Derailleur switched between energy storage and release modes.