

# Shijie Gao

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<https://shijiegao.github.io/>



Autonomy | Learning-based Control | Adaptive Planning | Motion Prediction | Robotic Swarms | UGV & UAV Research

I'm actively looking for **Autonomy Research/Engineer** position starting in **May 2024**.

## RESEARCH INTEREST

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The main objective of my research is to establish a foundation for **autonomous mobile systems** to **predict, detect, adapt, and recover against failures and changes in systems' dynamics at runtime** while ensuring **safety**. My research focuses on developing **learning-based control** and **safe planning** techniques, incorporating principles from machine learning, optimal control, motion planning, reachability analysis, and transfer learning.

My collaboration works extend into the areas of **robotic swarms**, cyber-physical systems (**CPS**) security, Human-robot interaction (**HRI**), and autonomous inspection, etc.,

## EDUCATION

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### University of Virginia

Doctor of Philosophy, Computer Engineering

*Aug. 2017 – May. 2024 (Expected)*

### Beijing Institute of Technology

Bachelor of Science, Automation

*Aug. 2013 – July, 2017*

### University of California Berkeley

Exchange Student, Electrical Engineering and Computer Science

*Aug. 2016 – May, 2017*

## SKILLS

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Proficient in **C++**, **MATLAB**, **Python**, Robot Operating System (**ROS1**, **ROS2**), **Gazebo**, **LINUX**

Proficient in **Assembling, Developing, Operating** and **Maintaining** a variety of robotic systems:

- **UGV**: Boston Dynamics Spot, Clearpath Jackal, Clearpath Ridgeback, Turtlebot 2/3/4, ROSBot, etc.,
- **UAV**: AscTec Hummingbird, AscTec Pelican, Crazyflie, DJI Matrice, DJI Mavi, Parrot Bebop, etc.,
- **Sensors**: RGB-D Camera, Thermal Camera, 2D/3D LiDAR, GPS etc.,
- **Other platforms**: Phidgets, DJI OSDK, Spot SDK, CasADi, Docker, Variety of Simulators, etc.,

## RESEARCH EXPERIENCE

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### University of Virginia, Autonomous Mobile Robots Lab

*Graduate Research Assistant*

*Charlottesville, VA*

*Jan. 2018 - Now*

- Developed novel control and path planning techniques that improve the safety and efficiency of autonomous robotic systems operations, aiming to solve general challenges in robotic applications (e.g. **state and uncertainty predictions, task allocation, efficient path planning, optimal control, degradation recoveries**, etc.,)
- Validate the proposed techniques by **rapidly prototyping** software to control robotic simulators.
- Create proof-of-concept tests, using high-fidelity simulators and real-world robotic systems.
- Complete projects that demonstrate the efficacy of the proposed techniques in an **efficient and timely manner**.
- Authored several papers that **effectively communicate** the key concepts, selected for publication in prestigious robotics conferences and journals.
- Rapidly designed, assembled, and configured robotic platforms, while **also developing API tools** and **ROS wrappers** to fulfill the requirements of both lab projects and course teaching.
- Mentoring undergraduate capstone teams.

## SELECTED RESEARCH

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### **Bridging the Gap for Sim2Real and Real2Real Transfer Learning Challenges**

S. Gao, and N. Bezzo, 2021 IEEE/RSJ International Conference on Intelligent Robots and Systems (*IROS 21'*) and under review for Journal of Intelligent & Robotic Systems (*JINT*)

- Proposed a novel **conformal mapping-based** transfer framework that **rapidly adapts** the control and path planning policy across systems with different dynamics, bypassing accurate model learning.
- Optimal Control, Model Predictive Control (MPC), **Motion Primitives Planning**, Complex Analysis
- C++, Python, CasADi NLP, MATLAB, ROS; UGV

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### **Sampling-Based Next-Best-View Task and Motion Planning for Autonomous Photography & Inspection**

S. Gao, L. Bramblett, and N. Bezzo, in *IROS 23' Workshop* and under review for *IROS 24'*

- Presented a runtime task and motion planner using a proposed **spatial information gain** for choosing optimal inspection points in **partially known** environments with unknown obstacles and occlusion, ensuring thorough inspection with **minimum** number of photos.
- Gaussian Process (GP), **raytracing**, Derivative-free Optimization, Hybrid A\*, RRT\*
- C++, Python, MATLAB, ROS, Gazebo; UGV, UAV, Lidar, RGB-D camera, GPS

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### **Meta-Learning-based Proactive Monitoring and Planning for Autonomous Systems under Degradations**

S. Gao, E. Yel, and N. Bezzo, in *IEEE Robotics and Automation Letters (RA-L)*

- Proposed a **Meta-Learning** based framework to predict and monitor the system's future states and state uncertainties under unforeseen actuator faults. Assuring the system safety by proactively replanning waypoints to prevent potential collisions.
- Model-Agnostic Meta-Learning (MAML), Mini-Jerk Trajectory Generation, **Runtime Model Adaption**
- Python, TensorFlow, ROS, Gazebo, MATLAB; UAV

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### **Exploiting Air Dynamic Changes for Reliable and Efficient Autonomous UAV Motion Planning**

S. Gao, C. Di Franco, D. Carter, D. Quinn, and N. Bezzo, in *ICUAS 19'*

- Designed a novel physical testbed for characterizing the ground and the ceiling effects for quadrotors. Proposed an **energy-efficient path planning** (up to **13%** energy reduction) strategy based on the analyzed airflow dynamics. Additionally, developed a **sensor-less** surface detection and landing method to enhance safety in quadrotor operation.
- Optimal Control, Polynomial Regression, Dijkstra
- Python, ROS, MATLAB; UAV

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### **Epistemic Prediction and Planning for Robotic Swarms in Communication Restricted Environments**

L. Bramblett, S. Gao, N. Bezzo, in 2023 IEEE International Conference on Robotics and Automation (*ICRA 23'*)

- Proposed a novel **epistemic planning** framework using **dynamic epistemic logic** for **distributed consensus-based planning**. The framework addresses generalized task allocation and space coverage problems, considering connectivity constraints and team dynamics.
- Distributed Control, Dynamic Epistemic Logic, Artificial Potential Field
- Python, MATLAB, ROS; Robotic Swarm

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### **A Data-Driven Framework for Proactive Intention-Aware Motion Planning in Human Environment**

R. Peddi, C. Di Franco, S. Gao, and N. Bezzo, in *IROS 20'*

[Human Robot Interaction]

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### **Detection of Nonrandom Sign-Based Behavior for Resilient Coordination of Robotic Swarms**

P.J. Bonczek, R. Peddi, S. Gao, and N. Bezzo, in IEEE Transactions on Robotics (**T-RO**)

[CPS Security]