Shubh Gupta

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Current Position

Stanford University   Oct 2023–Present
Post-Doctoral Fellow, Aeronautics and Astronautics
Faculty Sponsor: Grace X. Gao

Education

Stanford University   Sep 2019–Sep 2023
PhD, Electrical Engineering
Thesis: *High-Integrity Urban Localization: Bringing Safety in Aviation to Autonomous Driving*
Advisor: Grace X. Gao

Stanford University   Sep 2019–Jan 2021
Master of Science, Electrical Engineering

University of Illinois at Urbana-Champaign   Aug 2018–Sep 2019
Graduate Student, Electrical and Computer Engineering
Advisor: Grace X. Gao

Indian Institute of Technology, Kanpur   May 2014–June 2018
Bachelor of Technology, Electrical Engineering, Minor Computer Architecture   GPA: 9.3/10.0

Research Interests

Navigation systems that assist with diverse real world applications while meeting their stringent requirements.
Areas of focus: Environmental representations, safety protocols, sensor processing algorithms, and their interplay.

Research Experience

Stanford University at NAVLab   Sep 2019–Present
Graduate Research Assistant (with Grace Gao)   Stanford, California

Safety Assessment Using Environmental Knowledge

- Devised reinforcement learning-based sampling techniques for efficient and accurate risk estimation in complex scenarios involving autonomous agents

- Built a comprehensive simulation framework for efficient and automated stress testing of autonomous vehicles across diverse traffic scenarios, environmental conditions, road agents, and sensor errors

- Estimated high-confidence localization error bounds using camera images and a point cloud environment map, combining model-based and data-driven uncertainties

- Predicted GNSS signal blockage using Neural Radiance Field (NeRF) environmental representations and analyzing obstruction along signal paths

Real-time Monitoring with Imperfect Sensors and Algorithms

- Designed a state estimation algorithm fusing GPS, camera, and IMU data, emphasizing error bound estimation in urban environments using statistical variance reduction techniques

- Introduced a safety-driven filtering framework, designed with a novel joint fault removal and localization optimization objective, to rectify GPS measurement errors in complex urban environments

- Formulated Bayesian and statistical learning bounds based on GPS measurements to trigger alerts for large location errors, reducing false positives by $> 90\%$ and keeping false negatives under 5%

Sensor-based Navigation Techniques Integrating Environment Models

- Proposed and implemented an ecosystem for creating, maintaining and using NeRF-based maps of cities, enabling robust localization using camera images
- Developed deep neural networks that learn implicit environmental models from measurement logs to enhance GNSS localization accuracy
- Designed hybrid classical and deep learning GNSS localization methods leveraging implicit environment models to improve model generalization and efficiency on resource-constrained hardware
- Developed a NeRF-based terrain representation and path planning framework for effective exploration of extraterrestrial surfaces, enabling the assimilation of new sensor data to inform rerouting

University of Illinois at Urbana-Champaign at GPS Lab   Aug 2018–May 2019
Graduate Research Assistant (with Grace Gao)   Champaign, Illinois

- Developed a Gaussian Mixture Model-based filtering algorithm with adaptive weights to mitigate GPS errors in urban environments
- Proposed a randomized perturbation-based algorithm to estimate the probability of large location errors

Ford Motor Company at Greenfield Labs   May–Aug 2019
Research Intern in Computer Vision   Palo Alto, California

- Developed GAN-based algorithms to generate realistic driving videos from simulations, using discriminators to evaluate combinations of image patches
- Devised methods for leveraging unpaired datasets to increase the variety and size of training data, improving the visual quality of generated videos

Teaching Experience

Teaching Assistant at Stanford University   Sep 2021–Dec 2021
Course: Navigation of Autonomous Systems, AA Department
- Delivered lectures on GNSS, ROS, and Deep Learning
- Designed and graded bi-weekly homeworks
- Interacted with students during weekly office hours

Teaching Assistant at Stanford University   Sep 2020–Dec 2020
Course: Navigation of Autonomous Systems, AA Department
- Sole TA for the first offering of the course
- Delivered lectures on GNSS, ROS, and Deep Learning
- Designed and graded bi-weekly homeworks
- Interacted with students during weekly office hours

Teaching Assistant at Stanford University   Jan 2020–March 2020
Course: Global Positioning Systems, AA Department
- Redesigned and graded homework assignments
- Interacted with students during weekly office hours

Mentoring Experience

Mentor for Adam Dai, Stanford PhD student (4th year)   Feb 2023–Present

Mentor for Daniel Neamati, Stanford PhD student (2nd year)   Jan 2023–Present

Mentor for Mira Partha, Stanford PhD student (3rd year)   Oct 2022–Present

Mentor for Siddhartha Jagannatha, Stanford undergrad student (senior year)   Sep 2021–Sep 2022
Current Status: Graduate student at Stanford

Mentor for Adyasha Mohanty, Stanford PhD student (1st year)   Sep 2020–Sep 2021
Current Status: Final year PhD candidate at Stanford

Awards and Honors

Best Presentation of the Session Award (2 papers), ION GNSS+ 2023   Sep 2023

Defense Innovation Scholar, Gordon Knot Center, Stanford University   Oct 2022

Best Presentation of the Session Award, ION GNSS+ 2022   Sep 2022

Academic Excellence Award, IIT Kanpur   June 2015 & 2016

Professional Service

Session Chair, ION GNSS+ 2023   Sep 2023

Newsletter Chair, Stanford Center for AI Safety   June 2023–Present

Student Moderator, 3rd NorCal Control Workshop   Jan 2021

Manuscript Reviewer:
    NAVIGATION: Journal of the Institute of Navigation
    IEEE International Conference on Robotics and Automation
    EURASIP Journal on Advances in Signal Processing
    Journal of Aerospace Information Systems
    Artificial Intelligence Journal
    IEEE Transactions on Aerospace and Electronic Systems

Journal Publications

S. Gupta, G. Gao, Reliable Urban Vehicle Localization Under Faulty Satellite Navigation Signals. *EURASIP Journal on Advances in Signal Processing*, October 2023. (submitted) https://doi.org/10.48550/arXiv.2101.06380.

S. Gupta, A. Mohanty, G. Gao, Urban Localization using Robust Filtering at Multiple Linearization Points. *EURASIP Journal on Advances in Signal Processing*, October 2023. https://doi.org/10.1186/s13634-023-01062-7.

S. Gupta*, A. Kanhere*, A. Shetty, G. Gao, Improving GNSS Positioning using Neural Network-based Corrections. *NAVIGATION: Journal of the Institute of Navigation*, December 2022. https://doi.org/10.33012/navi.548.

A. Mohanty, **S. Gupta**, G. Gao, A Particle-filtering Framework for Integrity Risk of GNSS-Camera Sensor Fusion. *NAVIGATION: Journal of the Institute of Navigation*, December 2021. https://doi.org/10.1002/navi.455.

S. Gupta, G. Gao, Data-Driven Protection Levels for Camera and 3D Map-based Safe Urban Localization. *NAVIGATION: Journal of the Institute of Navigation*, September 2021. https://doi.org/10.1002/navi.445.

R. Moss, **S. Gupta**, R. Dyro, K. Leung, M. Kochenderfer, G. Gao, M. Pavone, E. Schmerling, A. Corso, R. Madigan, M. Stroila, T. Gibson, Autonomous Vehicle Risk Assessment. *Stanford Center for AI Safety, Stanford University*, June 2021. Technical Report.

Preprints

A. Corso, K. Kim, **S. Gupta**, G. Gao, M. Kochenderfer, A Deep Reinforcement Learning Approach to Rare Event Estimation. arXiv:2211.12470 [cs.LG].

Conference Publications

D. Neamati, **S. Gupta**, M. Partha, and G. Gao, Neural City Maps for GNSS NLOS Prediction, *Proceedings of the 36th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2023, *pp. 2073-2087.* https://doi.org/10.33012/2023.19403

M. Partha, **S. Gupta**, and G. Gao, Neural City Maps: A Case for 3D Urban Environment Representations Based on Radiance Fields. *Proceedings of the 36th International Technical Meeting of the Satellite Division of The*

Institute of Navigation (ION GNSS+), September 2023, *pp. 1953-1973.* https://doi.org/10.33012/2023.19324

A. Dai, **S. Gupta**, and G. Gao, Neural Radiance Maps for Extraterrestrial Navigation and Path Planning. *Proceedings of the 36th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2023, *pp. 1606-1620.* https://doi.org/10.33012/2023.19202

S. Gupta, A. Mohanty, G. Gao, Getting The Best of Particle and Kalman Filters: GNSS Sensor Fusion using Rao-Blackwellized Particle Filter. *Proceedings of the 35th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2022, *pp. 1610-1623.* https://doi.org/10.33012/2022.18470.

S. Gupta, A. Kanhere, A. Shetty, G. Gao, Designing Deep Neural Networks for Sequential GNSS Positioning. *Proceedings of the 35th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2022, *pp. 1209-1219.* **(Best Presentation Award)**. https://doi.org/10.33012/2022.18494.

S. Gupta*, A. Kanhere*, A. Shetty, G. Gao, Improving GNSS Positioning using Neural Network-based Corrections. *Proceedings of the 34th International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2021, *pp. 3068-3080.* https://doi.org/10.33012/2021.17999.

A. Mohanty, **S. Gupta**, G. Gao, A Particle Filtering Framework for Integrity Risk of GNSS-Camera Sensor Fusion. *Proceedings of the 33rd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2020, *pp. 2440-2452.* https://doi.org/10.33012/2020.17660.

S. Gupta, G. Gao, Data-Driven Protection Levels for Camera and 3D Map-based Safe Urban Localization. *Proceedings of the 33rd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2020, *pp. 2483 - 2499.* https://doi.org/10.33012/2020.17698.

N. Jaipuria, **S. Gupta**, P. Narayanan, V. Murali, On the Role of Receptive Field in Unsupervised Sim-to-Real Image Translation. *Machine Learning for Autonomous Driving Workshop at the 33rd Conference on Neural Information Processing Systems (NeurIPS)*, December 2019. arXiv:2001.09257 [cs.CV].

S. Gupta, G. Gao, Particle RAIM for Integrity Monitoring. *Proceedings of the 32nd International Technical Meeting of the Satellite Division of The Institute of Navigation (ION GNSS+)*, September 2019, *pp. 811-826.* https://doi.org/10.33012/2019.16939.

P. Gupta, **S. Gupta**, A. Jayagopal, S. Pal, R. Sinha, Saliency Prediction for Mobile User Interfaces. *IEEE Winter Conference on Applications of Computer Vision (WACV)*, March 2018, *pp. 1529-1538.* https://doi.org/10.1109/WACV.2018.00171.

Invited Talks and Posters

S. Gupta, "Neural Radiance Field-based Maps for Navigation", Stanford Position, Navigation and Time Symposium, October 2023.

S. Gupta, "Data-Driven Protection Levels for Camera and 3D Map-based Safe Urban Localization", Institute of Navigation Webinar, November 2022. https://www.ion.org/publications/webinar-gupta.cfm

S. Gupta, "Incorporating Observation Noise in Adaptive Stress Testing of Autonomous Vehicles", Bay Area Robotics Symposium, October 2021.

S. Gupta, 'Adaptive Stress Testing of Autonomous Vehicles", SystemX Symposium, October 2021.

S. Gupta, "Particle RAIM", Stanford Position, Navigation and Time Symposium, October 2019.