KULBIR SINGH AHLUWALIA

Website ◇ Google Scholar ◇ GitHub
Urbana, Illinois, USA ◇ ksa5@illinois.edu

EDUCATION

Ph.D. in Computer Science, University of Illinois at Urbana-Champaign, USA (Jun 2022–Present), GPA: 3.91/4
M.Eng. in Robotics, University of Maryland, College Park, USA (Aug 2019–May 2021), GPA: 3.88/4
B.Tech. in Electrical Engineering, Punjab Engineering College, India (Aug 2015–May 2019), GPA: 8.12/10

RESEARCH PAPERS

- **Ahluwalia, K.S.***; Jain, C.*; Cuaran, J.; Gummadi, S.; McGuire, M.; Sivakumar, A.; Hockenmaier, J.; Chowdhary, G. WaypointGen++. (In Preparation for IEEE RAL)
- **Ahluwalia, K.S.***; Jain, C.*; Cuaran, J.; Gummadi, S.; McGuire, M.; Sivakumar, A.; Hockenmaier, J.; Chowdhary, G. WaypointGen: Learning Grounded Waypoint based Navigation for Mobile Manipulators. Coordinated Science Laboratory Student Conference (CSL SC) 2026, Machine Learning, Generative AI, and Signal Processing Session.
- Cuaran, J.; **Ahluwalia, K.S.**; Koe, K.; Uppalapati, N.K.; Chowdhary, G. Active Semantic Mapping with Mobile Manipulator in Horticultural Environments. (Accepted to ICRA 2025) [Project Website] [arXiv PDF] [arXiv]
- Rangwala, M.; Liu, J.; **Ahluwalia, K.S.**; Ghajar, S.; Dhami, H.S.; Tracy, B.F.; Tokekar, P.; Williams, R.K. DeepPaSTL: Spatio-Temporal Deep Learning Methods for Predicting Long-Term Pasture Terrains Using Synthetic Datasets. Agronomy 2021, 11, 2245. (published in Agronomy as part of the Special Issue AI and Agricultural Robots) [Link to published paper] [PDF]
- Liu, J.; Rangwala, M.; **Ahluwalia, K.S.**; Ghajar, S.; Dhami, H.S.; Tracy, B.F.; Tokekar, P.; Williams, R.K. "Intermittent Deployment for Large-Scale Multi-Robot Forage Perception: Data Synthesis, Prediction, and Planning", 2021. [arXiv] [PDF] (published at IEEE TASE, Transactions on Automation Science and Engineering)

WORK EXPERIENCE

AI Intern, Earthsense Inc., Urbana, IL, USA *May 2025–Aug 2025*

- Built an end-to-end ML pipeline for language-conditioned waypoint generation, integrating 2D and 3D planners into a production-oriented autonomy stack for mobile manipulator navigation.
- Deployed Grounded SAM2 for automated large-scale dataset labeling, increasing training-data throughput for vision-model development.
- Benchmarked and deployed six large-scale VLMs (Molmo-7B-D, Gemma-3-27B, Qwen-2.5-VL-72B, Qwen3-30B-A3B, Llama4-Scout, Spatial-VLM) on GPU infrastructure, comparing inference efficiency, memory behavior, and deployment tradeoffs for production use.

Teaching Assistant, CS444 & CS498GC, University of Illinois at Urbana-Champaign *Spring 2024, Spring 2025, Fall 2025, Spring 2026* **Courses:** Deep Learning for Computer Vision (CS444, Dr. Svetlana Lazebnik); co-developed CS498GC: Mobile Robotics (ROS2, MoveIt2, SLAM, mobile manipulators, Fall 2025). Highlight: SLAM-ing Mars. Nominated for TA award by Prof. Lazebnik (Spring 2025).

- Updated assignment starter code and assessed student submissions using Canvas.
- Provided support during in-person office hours and via Campuswire, addressing student queries and concerns.
- Designed and developed multimodal (Reasoning LLM/VLM proof) quiz questions, including single-choice, multiple-choice, and matching formats for students.

RESEARCH EXPERIENCE

University of Illinois, Distributed Autonomous Systems Lab *Aug 2022–present*
Graduate Research Assistant
Mentors: Dr. Girish Chowdhary & Dr. Julia Hockenmaier

- Built 3D volumetric scene representations and semantic voxel maps for autonomous robot navigation, processing multi-sensor data streams (LiDAR, RGB, IMU) in real time for spatial reasoning and scene understanding.
- Developed natural language-conditioned waypoint generation pipelines for mobile manipulators using VLM-based filtering, BEV representations, and MPPI trajectory selection, enabling vision-language grounded navigation in unstructured outdoor environments.
- Designed fault detection and recovery pipelines for distributed robotic systems, categorizing failure modes and building automated recovery for safety-critical autonomous operation.

University of Illinois, Distributed Autonomous Systems Lab *May 2021–Sep 2023*
Graduate Research Assistant
Mentors: Dr. Girish Chowdhary & Dr. Julia Hockenmaier

- Fine-tuned CodeT5 (transformer-based model) for natural language grounding and code generation tasks.
- Created large-scale datasets for grounding natural language commands to spatial locations and analyzed spatial data distributions.

University of Maryland, Robotics Algorithms & Autonomous Systems Lab *Jul 2020–Aug 2021*
Independent Study
Mentor: Dr. Pratap Tokekar

- Processed 3D point clouds from LiDAR-mounted quadcopters for realistic terrain simulation and large-scale environment modeling.
- Automated procedural simulation environment generation in Gazebo with diverse object configurations and poses.

University of Waterloo, Ontario, Canada *Mar–Jul 2018*
Visiting Scholar
Mentor: Dr. Simarjeet Saini

- Developed neural network-based sensor data analysis using scaled conjugate gradient backpropagation.
- Designed and 3D printed low-cost photonic sensing devices for non-destructive testing applications.

Indian Institute of Technology, Roorkee *Jun–Jul 2016*
Research Intern
Mentor: Dr. Dharmendra Singh

- Investigated electromagnetic simulation and the effect of radio wave absorbers on Radar Cross Section using Ansys HFSS.

RESEARCH ARTICLES AND ABSTRACTS

- Cuaran, Jose; Ahluwalia, Kulbir Singh; Koe, Kendall; Chowdhary, Girish. "Active Semantic Mapping with Mobile Manipulator in Horticultural Environments", 2024, Accepted at 40th Anniversary of the IEEE Conference on Robotics and Automation (ICRA@40)
- The multispectral Fundus Eye camera prototype was featured in the Optics and Photonics News (OPN) in February 2019 in "Saini, Simarjeet Singh, Aneesh Sridhar, and Kulbir Ahluwalia. "Smartphone optical sensors." Optics and Photonics News 30, no. 2 (2019): 34-41." [Link to article] [PDF]

CONFERENCE PRESENTATION

- Yuqi Li, Kulbir S. Ahluwalia, and Simarjeet S. Saini. "Reinforcement learning integrated with supervised learning for training of near infrared spectrum data for non-destructive testing of fruits." (Reinforcement learning for sensor-based quality assessment) In Sensing for Agriculture and Food Quality and Safety XII, vol. 11421, p. 114210J. International Society for Optics and Photonics, 2020. [Link to conference presentation]

TECHNICAL SKILLS

Languages	Python, C++, MATLAB
Frameworks	PyTorch, JAX, TensorFlow, Transformers, Diffusers, CUDA, Stable Diffusion
Robotics	ROS, ROS2, MoveIt, MoveIt2, RViz, RViz2, Gazebo, Blender, Docker, Linux, Git
Probabilistic/RL	EKF, GMM/EM, MDPs, Bayesian State Estimation, Policy Optimization
Libraries	NumPy, OpenCV, SciPy, Pandas, scikit-learn
Tools	LaTeX, distributed computing, GPU infrastructure, data pipelines, cloud platforms

PROJECTS

- **Enhancing Stereo Depth Maps through RGBD-Conditioned Generative Models** *Aug–Dec 2024*
  - Designed a conditional diffusion model fusing RGB and noisy stereo depth inputs to generate accurate metric depth maps.
  - Fine-tuned Stable Diffusion V2 (Marigold-style training pipeline) on SimSense simulation data for realistic depth synthesis.
  - Outperformed Marigold and Depth-Anything-V2 on IRS, VKITTI, and NYUv2 benchmarks by up to 46% Abs Rel improvement.
- **Lane Detection and Turn Prediction for Self-Driving Car** *March 2020*
  - Developed lane detection using histogram-based sliding window analysis and polynomial curve fitting for autonomous driving perception.
  - Implemented bird's-eye-view perspective transform for lane visualization.
- **Visual Odometry for Vehicle Motion Estimation** *May 2020*
- **SLAM from 2D LiDAR Data using Split-and-Merge Line Extraction** *Dec 2021*
- **Multi-Sensor Fusion via Extended Kalman Filter (GPS+Encoder)** *Nov 2021*
- **RTK-GPS, IMU, and Encoder Trajectory Estimation for Autonomous Vehicle** *Sep 2021*
- **Multi-Agent Coordination: Persistent Monitoring using UAV-UGV Systems** *Dec 2020*
- **GestureGAN Optimization for Efficient Inference** *Dec 2020*
  - Optimized cross-view image generation using MobileNet backbone, achieving 5.7X parameter reduction while preserving quality.
- **Image Segmentation using Superpixels** *Dec 2020*
  - Built segmentation pipeline using SLIC superpixels with VGG16 feature extraction.
- **Color-Based Probabilistic Segmentation via GMM/EM** *2020*

  - Implemented Gaussian Mixture Models with Expectation-Maximization for probabilistic color segmentation in video sequences.
- **VAE and GAN Implementation** - Implemented VAE & GAN architectures for image generation. *March 2023*
- **RESNet Implementation** - Implemented ResNet for classification on MNIST dataset. *Feb 2023*
- **Autonomous Vehicle Delivery Robot** *May 2021*
  - Designed an autonomous robot with navigation, localization (QR codes), and multi-sensor perception (RGB camera, IMU, encoders, ultrasonic).
- **A* Path Planning on Turtlebot 3** - Path planning with non-holonomic constraints. *May 2020*

COURSEWORK

Graduate (UIUC): CS598SHW: 3D Vision, CS598YL: Deep Learning for Robotic Manipulation, Deep Learning for Computer Vision (CS444), Machine Learning (CS446), Advanced NLP (CS546), Natural Language Processing (CS447), Mobile Robotics (CS498GC), Autonomous Systems and Robots.

Graduate (UMD): Visual Learning and Recognition, Perception for Autonomous Robots, Autonomous Robotics, **Decision Making for Robotics**, Planning for Autonomous Robots, Control of Robotic Systems, Robot Modelling, Robot Programming, Building Robot Software Systems.

Undergraduate (PEC): Neural Networks and Fuzzy Systems, Advanced Control Systems, Microprocessors and Interfacing, Power Electronics, Mechatronics, Python Programming.

ADDITIONAL PROJECTS

- **AR-Tag Detection** - superimposed an image and virtual cube on an AR tag.
- **Object Tracking using Lucas-Kanade Tracker**
- **Baxter Robot Simulation in Gazebo** - ROS-based pick-and-place in simulation.
- **Path Planning using Dijkstra's Algorithm**
- **ARIAC 2019** - Industrial automation with UR10 arms, conveyor belts, and AGVs.
- **PID Controller for Turtlebot 3**
- **UR5 Arm Simulation in RViz** - 6-DOF arm with DH parameters and forward kinematics.
- **Teleoperated Gesture-Controlled Robotic Arm**

LEADERSHIP AND TEACHING EXPERIENCE

- Served as **Technology Head for Hardware domain** for IEEE PEC Student branch. Conducted workshops on making a "Pick n Place Transporter Robot" and "Using the Raspberry Pi".
- Taught Math and Science to government high school students as part of "PUNARKRITI Welfare Society" (Jan–Apr 2016) and "Junior Einstein" (Dec 2018).

OTHER ACHIEVEMENTS AND AWARDS

- First prize in MAJOR PROJECT in the B.Tech. Examination of Electrical Engineering, 2015–19 for "Teleoperated Gesture controlled Robotic arm". [May 2019]
- Received Certificate of Appreciation for contributions to IEEE PEC. [Aug 2017, Aug 2018]
- Awarded with the **National Bal Shree Award in Creative Scientific Innovations** by the Ministry of Human Resource Development, Govt. of India conferred by the President of India.

MENTORING

- **Chahit Jain** (CS + Statistics, Junior at UIUC)
  Co-first-author on WaypointGen++ (In Preparation for IEEE RAL) and WaypointGen (CSL SC 2026, Accepted Poster). Contributed VLM-based filtering, BEV waypoint extraction, and MPPI trajectory selection modules.
- **Gurmanat Singh Kahlon** (CS, BS, University of Toronto)
  Guidance on robotics research directions and graduate school applications.

CONFERENCE REVIEWS

- Workshop on Agricultural Robotics for a Sustainable Future, IROS [Reviewer]
- ICDL 2025 - 2025 IEEE International Conference on Development and Learning (ICDL) September 16-19, 2025, Prague, Czechia [Reviewer]