KULBIR SINGH AHLUWALIA

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EDUCATION

Ph.D. in Computer Science, University of Illinois at Urbana-Champaign, USA (June 2022 - Present, Expected May 2027), GPA: 3.91/4
Advisors: Dr. Girish Chowdhary & Dr. Julia Hockenmaier
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.***; Gummadi, S.; Cuaran, J.; McGuire, M.; Hockenmaier, J.; Chowdhary, G. Learning Natural Language Conditioned Waypoint Generation in 2D Image Space for Agricultural Mobile Robots. (Submitting to RSS 2026, Dec 8, 2025) **First Author*
- 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*

- Developed OmniBot, a 7-stage VLM-based pipeline for natural language conditioned waypoint generation in 2D image space, achieving 90% success rate in field trials across palm plantations, solar farms, and vineyards.
- Deployed 6 open-source VLMs (Molmo-7B, Gemma-3-27B, Qwen-2.5-VL-72B, Qwen3-30B, Llama4-Scout, SpatialVLM) on Jetson AGX Orin, achieving 3.8-5.6 FPS for real-time robot navigation.
- Created automated labeling pipeline using Florence2, DINO-X, and Grounded SAM2, reducing dataset preparation from 6 weeks to 1 day for 10K+ navigation images.
- Reduced agricultural robot deployment time from 3 months to 1-2 weeks through NL-conditioned navigation.

Teaching Assistant, CS498GC: Mobile Robotics, UIUC *Aug 2025 - Dec 2025*
Instructor: Dr. Girish Chowdhary

- Co-developed ROS2-based curriculum covering odometry, Extended Kalman Filter sensor fusion, SLAM, and mobile manipulation with 13-DOF Husky-UR3 simulation.
- Built comprehensive autograding infrastructure for coding exercises on Gradescope with physics-based verification.
- Created 44 Campuswire posts with debugging guides identifying top failure patterns (80% of student errors).
- Developed cross-platform launcher scripts for macOS/Linux supporting Apple Silicon and NVIDIA GPUs.
- Designed Assignment 4: Mobile Manipulator project integrating Husky base + UR3 arm + parallel gripper in Gazebo.

Teaching Assistant, CS519: Scientific Visualization, UIUC *May 2025 - Aug 2025*
Instructor: Dr. Eric Shaffer

- Created multimodal exam questions with integrated Python/matplotlib visualizations for assessing scientific visualization concepts.
- Assisted students with implementation of ray marching, transfer functions, and interactive widget development.

Teaching Assistant, CS444: Deep Learning for Computer Vision, UIUC *Jan 2024 - May 2024, Jan 2025 - May 2025*
Instructor: Dr. Svetlana Lazebnik

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

RESEARCH EXPERIENCE

University of Illinois, Distributed Autonomous Systems Lab *Aug 2022-present*
Graduate Research Assistant
Mentors: Dr. Girish Chowdhary & Dr. Julia Hockenmaier
- Investigated 3D semantic representations for robot environment mapping and relocalization after failure.
- Categorized recovery action sequences for various failure cases and constructed topological maps for visual language navigation.

University of Illinois, Distributed Autonomous Systems Lab *May 2021-Sep 2023*
Graduate Research Assistant
Mentors: Dr. Girish Chowdhary & Dr. Julia Hockenmaier
- Fine-tuned CodeT5 for natural language grounding and code generation.
- Created datasets for grounding natural language commands and analyzed location data distributions.
- Developed a Python package for the farmbot agricultural robot.

University of Maryland, Robotics Algorithms & Autonomous Systems Lab *Jul 2020-Aug 2021*
Independent Study
Mentor: Dr. Pratap Tokekar
- Processed point clouds from LiDAR-mounted quadcopters for pasture simulation.
- Automated gazebo world construction for grass pastures with unique plant poses.

University of Waterloo, Ontario, Canada *Mar-Jul 2018*
Visiting Scholar
Mentor: Dr. Simarjeet Saini
- Developed an orange sweetness detector using scaled conjugate gradient backpropagation.
- Designed, programmed and 3D printed low-cost photonic devices, including a urea-in-milk detector and a fundus eye camera.

Indian Institute of Technology, Roorkee *Jun-Jul 2016*
Research Intern
Mentor: Dr. Dharmendra Singh
- Investigated 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." 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
VLMs/LLMs	Qwen-2.5-VL-72B, Molmo-7B, Gemma-3, Llama4-Scout, Spatial-VLM, Florence2, DINO-X
Libraries	PyTorch, HuggingFace Transformers, vLLM, NumPy, OpenCV, SciPy, Grounded SAM2
Robotics	ROS2 (Humble, Jazzy), Gazebo, RViz2, MoveIt2, ros2_control, Nav2
Other	CUDA, Linux, Docker, Git, Jetson AGX Orin, LaTeX, Blender, Solidworks

PROJECTS

- **13-DOF Mobile Manipulator Simulation (Fall 2025):**
  - Integrated Husky mobile base (6-DOF SE(3)) + UR3 arm (6-DOF) + parallel jaw gripper (1-DOF) in Gazebo.
  - Implemented ros2_control with velocity command interfaces for base navigation and arm manipulation.
  - Created GPU-optimized and software-rendering launch configurations for NVIDIA and Apple Silicon.
- **EKF Sensor Fusion Implementation (Fall 2025):**
  - Implemented 16-state Extended Kalman Filter fusing GPS, IMU, and wheel encoders for robot localization.
  - Achieved robust state estimation with gyroscope-based heading updates at 10Hz.
  - Developed autograder with physics-based verification for student submissions.
- Enhancing Stereo Depth Maps through RGBD-Conditioned Generative Models (Aug-Dec 2024):
  - Conditional diffusion model fusing RGB and noisy depth for metric maps.

  - Fine-tuned Stable Diffusion V2 (similar to Marigold Training Pipeline) using SimSense simulation.
  - Outperforms Marigold/Depth-Anything-V2 on IRS, VKITTI, NYUv2 by up to 46% Abs Rel.
- **SLAM from 2D LiDAR data using split and merge line extraction algorithm**
- **State estimation using Extended Kalman Filter for GPS+IMU+Encoder sensor fusion**
- **Processed data from RTK-GPS, IMU and encoders to plot trajectory of a field robot**
- **Autonomous Vaccine Delivery Robot**
- **Image segmentation using superpixels**
- **Persistent-Monitoring using Multi-Robot (UAV-UGV) Coordination**
- **Optimized a GestureGAN for resource constrained settings**
- **Self-adjusting roadmaps** - Navigation in unknown environments using LD-PRM.
- **Estimated the motion of a car using Visual odometry**

COURSEWORK

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

Graduate (UMD): Autonomous robotics, Decision making for robotics, Visual Learning and recognition, Planning for Autonomous Robots, Perception 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, Engineering analysis and design, Manufacturing, Biomedical engineering, Electromagnetic theory, Python Programming.

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" to share our team's experiences and techniques with our juniors in PEC.
- Taught Math and Science to government high school students as part of "PUNARKRITI Welfare Society" (Jan-Apr 2016) and "Junior Einstein" (Dec 2018) social welfare organizations.

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.

ADDITIONAL PROJECTS

- **AR-Tag detection** - superimposed an image and virtual cube on an AR tag.
- **Tracked moving objects using Lucas-Kanade Tracker**
- **Baxter transporting cubes in Gazebo**
- **Implemented A star algorithm for Path Planning on Turtlebot 3**
- **Path planning for point and rigid robot using Djikstra's Algorithm**
- **Lane detection and Turn prediction for self driving car**
- **Agile Robotics for Industrial Automation Competition (ARIAC) 2019**
- **Designed a PID controller for Turtlebot 3**
- **Modelled a UR 5 arm with Parallel Gripper in Rviz**
- **Teleoperated gesture controlled robotic arm**
- **Pick n place transporter bot**
- **Smart Garden**