KULBIR SINGH AHLUWALIA

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EDUCATION

PhD in Computer Science *June 2022-present*
University of Illinois, Urbana-Champaign, USA GPA: **3.91/4**

Master of Engineering in Robotics *Aug 2019-May 2021*
University of Maryland, College Park, USA GPA: **3.88/4**

B.Tech in Electrical Engineering *Aug 2015-May 2019*
Punjab Engineering College, India GPA: **8.12/10**

RESEARCH PAPERS

- 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) [PDF]
- Rangwala, M.; Liu, J.; **Ahluwalia, K.S.**; Ghajar, S.; Dhami, H.S.; Tracy, B.F.; Tokekar, P.; Williams, R.K. Deep-PaSTL: 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 Transactions on Automation Science and Engineering)

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]

EXPERIENCE

University of Illinois, Teaching Assistant for CS444: Deep Learning *Jan 2024 - May 2024, Jan 2025 - Present*
Course: CS444 - Deep Learning for Computer Vision
Instructor: Dr. Svetlana Lazebnik

- Updated and verified starter code for assignments, and answered student questions during office hours and through Campuswire.
- Assessed student submissions via SpeedGrader on Canvas, and designed multimodal quiz questions, including single-choice, multiple-choice, and matching formats.

University of Illinois, Distributed Autonomous Systems Lab *Aug 2022-present*
Remote Recovery using NL grounding and 3D Semantic fields for mobile robots, Graduate Research Assistant
Mentors: Dr Girish Chowdhary & Dr Julia Hockenmaier

- Working on use of 3D, dynamic, semantic representations for objects and grounded 3D voxel value maps for the robot's environment. Goal is to relocalize the robot after a failure case for remote robot recovery.
- Categorized and collected manual recovery action sequences for majority of failure cases arising from visual occlusions, sensor noise, incorrect state estimation, planning or unexpected mechanical failure cases.
- Constructed topological maps from Rosbags for Visual language navigation and grounding using IMU, GPS location, front and rear RGB camera images. Added images and vertices to the topological graph of our collected dataset where natural language descriptions of landmark objects are grounded in the graph using CLIP.
- Collected data using Gazebo simulation of a mobile robot traversing field plots for remote robot recovery.

University of Illinois, Distributed Autonomous Systems Lab *May 2021-Sep 2023*
Plant Placement in Simulations using NL Grounding, Graduate Research Assistant
Mentors: Dr Girish Chowdhary & Dr Julia Hockenmaier

- Fine-tuned CodeT5 to learn the mapping from (NL, Env State) to (Code). Generated code includes arguments that satisfy the relative spatial references, physical and natural language constraints.
- Generated additional dataset for grounding natural language commands that require the use of robot state for plant placement task using multiple references.

- Analyzed the distribution of generated location data for relative spatial description commands.
- Built a python package and wrapper to interface with the agricultural robot known as the farmbot.

University of Maryland, Robotics Algorithms & Autonomous Systems Lab *Jul 2020-Aug 2021*
Independent study , **Mentor: Dr Pratap Tokekar**
- Processed point clouds of the pasture obtained from the gazebo simulation for selected days of a year using LiDAR mounted on the hector quadcopter controlled using an autonomous navigation script.
- Automated the task of constructing gazebo worlds for grass pastures where each plant has a unique pose and is scaled to match real world height data of a location.

University of Waterloo, Ontario, Canada *Mar-Jul 2018*
Visiting Scholar , **Mentor: Dr Simarjeet Saini**
- Developed an orange sweetness detector which used scaled conjugate gradient backpropagation in MATLAB to non-destructively predict sweetness of oranges with an accuracy of 70%. Discrete cosine transform was used to reduce dimensions of input matrix and prevent memory overflow.
- Designed prototypes in Solidworks, which were 3D printed using the Ultimaker 3. Developed low-cost photonic devices like Urea in milk detector and the Fundus eye camera. The Fundus eye camera used Raspberry Pi3 to capture images and videos of the retina of a model eye to aid in diagnosis of diseases.

Indian Institute of Technology, Roorkee *Jun-Jul 2016*
Research Intern, **Mentor: Dr Dharmendra Singh**
- Varied the thickness of radio wave absorbers such as nickel ferrite on a UAV model and its individual parts like cylindrical body, spherical nose and cuboidal wings and detected its effect on the Radar Cross Section in Ansys HFSS.

TECHNICAL SKILLS

Languages	Python, MATLAB, C++
Analysis & Design	Simulink, Blender, AutoCAD, Solidworks, Ultimaker Cura, Adobe Premiere Pro
Libraries	Torch, Transformers, Numpy, Pandas, OpenCV, SciPy
Other	ROS, Gazebo, RViz, CUDA, Linux, Docker, Git, Doxygen, Anaconda, LaTeX

COURSEWORK

Graduate (UIUC): CS598WY: Haptics and Tactile Sensing, CS598YL: Deep Learning for Robotic Manipulation, Advanced NLP (CS546), Machine Learning (CS446), Deep learning for Computer vision (CS444), Natural language processing (CS447), Mobile Robotics (CS498GC), 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.

PROJECTS

Enhancing Stereo Depth Maps through RGBD-Conditioned Generative Models	*Aug-Dec 2024*
Active Semantic Mapping with Mobile Manipulator for Precision Agriculture	*Jan-May 2024*
Turning Zero Shot into Few Shot via Self-prompting	*Aug-Dec 2023*
Implemented Linear, Logistic, Polynomial regression, SVM, Convolutional, and Attention based models	*Apr-May 2023*
VAE and GAN implementation - Implemented VAE & GAN for digit generation task.	*March 2023*
RESNet implementation - Implemented RESNet for classification task on MNIST dataset.	*Feb 2023*
Neural transition-based dependency parser	*Dec 2022*
Machine translation with RNN and Transformers	*Nov 2022*
Text classification with CNN and RNN	*Oct 2022*
SLAM from 2D LiDAR data using split and merge line extraction algorithm	*Dec 2021*
State estimation using Extended Kalman Filter for GPS+IMU+Encoder sensor fusion	*Nov 2021*
Processed data from RTK-GPS, IMU and encoders to plot trajectory of a field robot	*Sep 2021*
Autonomous Vaccine Delivery Robot	*May 2021*

- Designed an autonomous robot capable of navigating and localizing itself in a test arena using QR codes and arrows. It used a RGB camera, IMU, optical encoders and an ultrasonic sensor to detect, retrieve and transport user specified blocks from a collection zone to a drop-off zone.
  [Featured semester video] [Robot videos] [Featured post]

Image segmentation using superpixels *Dec 2020*

- Built a segmentation network using SLIC superpixels as input. A pretrained VGG16 network is used with its last few layers replaced by fully connected layers to classify superpixels into classes. (Accuracy 98%)

Persistent-Monitoring using Multi-Robot (UAV-UGV) Coordination *Dec 2020*

Optimized a GestureGAN for resource constrained settings *Dec 2020*
- Used MobileNet to optimize cross-view image generation with a 5.7X reduction in parameters.

Self-adjusting roadmaps - Navigation in unknown environments using LD-PRM. *May 2020*

Estimated the motion of a car using Visual odometry *May 2020*

Color segmentation using Gaussian mixture models & Expectation maximization *April 2020*

Image Classification using CNN *May 2020*

AR-Tag detection - superimposed an image and virtual cube on an AR tag. *March 2020*

Tracked moving objects using Lucas-Kanade Tracker *April 2020*

Baxter transporting cubes in Gazebo *April 2020*
- Simulated a Baxter robot transporting cubes from one table to another in Gazebo using ROS Kinetic. The waypoints for moving the baxter arm were found out using Rviz. The gazebo world had custom designed obstacles which were avoided by the baxter arm.

Implemented A star algorithm for Path Planning on Turtlebot 3 *May 2020*
- Implemented the A* algorithm for the Turtlebot 3 in a configuration space with obstacles. The Turtlebot 3 is bound by non holonomic constraints while the action set consists of 8 combinations of two user-defined RPMs.

Path planning for point and rigid robot using Djikstra's Algorithm *April 2020*

Lane detection and Turn prediction for self driving car *March 2020*
- Developed an algorithm that used hough transform and histogram of lanes approach.
- Implemented homography and warp perspective functions from scratch to create overlays.

Agile Robotics for Industrial Automation Competition (ARIAC) 2019 *May 2020*
- Developed an industrial system consisting of UR 10 robotic arms, conveyor belts and Autonomous Ground Vehicles (AGVs).
- Enabled the system to pick required parts from the conveyer belt, dispose faulty parts, assemble orders and deliver them using AGVs.

Designed a PID controller for Turtlebot 3 *April 2020*

Modelled a UR 5 arm with Parallel Gripper in Rviz *Sep-Dec 2019*
- Simulated a 7 DOF UR5 arm using Moveit and Rviz. Calculated the DH parameters, computed forward kinematics manually and verified the results using the Peter Corke Robotics toolbox in MATLAB.
  [Simulation videos]

Designed a LQR and LQG controller - for two inverted pendulums on a moving cart. *Dec 2019*

Teleoperated gesture controlled robotic arm *Aug 2018-May 2019*
- Engineered a prototype capable of transporting objects from one room to another using web-based remote access with live video feed and a gesture controlled robotic arm. With on-board power supply and a bright custom designed constant current LED light source, our robot was able to navigate through low light areas.
- The robot could be controlled using any smart device and also had a speaker to play prerecorded messages to interact with people around the robot.

Pick n place transporter bot - First Prize in IIT Roorkee; 6th/400 teams at IIT Bombay. *Aug-Dec 2016*

Smart Garden - First Prize in Texas Instruments Hardware Hackathon. *March 2017*

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".
- Received Certificate of Appreciation for contributions to IEEE PEC twice. (Aug 2017, 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.