Het Maheshkumar Sekhalia

hsekhali@andrew.cmu.edu | 412-844-0742 | linkedin.com/in/het-sekhalia | hetsekhalia.github.io

EDUCATION

Carnegie Mellon University Pittsburgh, PA
Master of Science in Mechanical Engineering-Research | *GPA: 3.95/4.0* May 2026
Relevant Coursework: Deep Reinforcement Learning, Planning and Decision-making in Robotics, Modern Control Theory, Intro to Deep Learning, Computer Vision, Electromechanical Systems Design, Probability and Estimation Methods for Engineering Systems

Indian Institute of Technology (IIT) Indore Indore, India
Bachelor of Technology in Mechanical Engineering | *GPA: 8.57/10* May 2024
Relevant Coursework: Instrumentation and Control System, Numerical Methods, Machine Design, Machining Science and Metrology

PROFESSIONAL EXPERIENCE

Komatsu Ltd. Pittsburgh, PA
Graduate Researcher, CERLAB – Prof. Kenji Shimada Nov 2024 - Present

- Engineered a modular autonomy stack for an autonomous wheel loader to perform loading and dumping, covering full trajectory planning, smoothing, and closed-loop control within a ROS2 + Isaac Sim simulation environment
- Designed kinematically feasible trajectories using RRT, RRT*, and Hybrid A* algorithms for the vehicle's articulated steering model
- Applied B-spline smoothing and velocity profiling to generate dynamically feasible reference paths for downstream control
- Implemented a nonlinear model predictive controller (NMPC) with real-time feedback using the ACADO toolkit
- Deployed a nonlinear MPC in ROS2 and architected a dual-Docker integration with Isaac Sim for real-time closed-loop simulation

PROJECTS

CLIP-Guided Pretraining for Physics-Based Humanoid Control Nov 2025 – Dec 2025

- Proposed a CLIP-guided pretraining strategy that leverages semantic motion similarity to accelerate physics-based humanoid learning
- Biased multi-task pretraining using CLIP text embeddings and fine-tuned PPO and TD3 agents on complex skills
- Achieved faster convergence and higher final returns than uniform pretraining or training from scratch via ablations over sampling temperature, motion diversity, and agent choice

Coverage Path Planning for Spray-Based 3D Concrete Printing Nov 2025 – Dec 2025

- Reframed spray-based concrete deposition as a hierarchical coverage planning problem optimizing spatial coverage, overspray reduction, and execution efficiency
- Developed a BFS + A* planner with an overspray-aware cost function to generate adaptive interior coverage paths
- Reduced simulated overspray from 32% to 13% while maintaining ~97% coverage and cutting waypoint count by over 50% relative to a lawnmower baseline
- Validated robustness across symmetric and asymmetric geometries and multi-layer builds, achieving uniform deposition and stable height accumulation

Model-Based Reinforcement Learning for Robotic Manipulation (PETS) Oct 2025

- Formulated a model-based control pipeline integrating learned probabilistic dynamics with MPC-based trajectory optimization
- Trained probabilistic ensemble dynamics models and integrated Cross-Entropy Method planning within MPC, substantially outperforming random sampling under deterministic and noisy dynamics
- Performed rollout and data-mixing ablations to expose model-error accumulation and optimal planning regimes

Imitation Learning & Black-Box Optimization for Control Oct 2025

- Architected a unified learning-based control framework combining black-box optimization, imitation learning, and diffusion policies, with rigorous quantitative evaluation on CartPole and BipedalWalker environments
- Deployed a from-scratch CMA-ES optimizer for policy search, rapidly attaining near-optimal performance with minimal iterations
- Developed and compared Behavior Cloning, DAgger, and transformer-based diffusion policies, analyzing convergence behavior, reward distributions, and inference-time trade-offs across action horizons

Sampling-Based Motion Planning for High-DoF Robotic Arms Oct 2025

- Implemented RRT, RRT-Connect, RRT*, and PRM planners to generate collision-free motion for high-DoF robotic arms
- Optimized joint-space sampling, nearest-neighbor search, and edge validation to meet strict 5-second planning budgets
- Evaluated planners across randomized start-goal pairs, quantifying trade-offs between speed, solution quality, and consistency, and identifying RRT-Connect and RRT as optimal for fast versus smooth motion

Real-Time Pursuit Planning in Dynamic Environments Sep 2025

- Designed a two-stage pursuit planner to intercept a moving target in large, cost-weighted grid worlds under strict real-time constraints
- Synthesized global cost-to-go maps via Dijkstra and identified time-feasible interception points, optimizing wait placement to reduce travel and delay costs
- Fortified the planner using multi-goal A fallback and path reuse, ensuring robust interception under tight runtime constraints

Deep Q-Networks (DQN) for Control Sep 2025

- Implemented DQN and Double DQN agents with experience replay and greedy exploration, assessing stability in control tasks
- Mitigated overestimation bias by integrating Double DQN into the baseline, decoupling action selection from evaluation to deliver more stable and reliable learning outcomes
- Benchmarked DQN and Double DQN against REINFORCE and N-step A2C agents using a custom evaluation framework with 5×1,000 training episodes, periodic rollouts, and performance visualizations across trials

Policy Gradient RL for Control Aug 2025

- Developed and evaluated a suite of deep reinforcement learning agents to solve CartPole-v1, applying policy-gradient methods
- Engineered REINFORCE, REINFORCE with Baseline, and N-step A2C in PyTorch, with a modular architecture for easy experimentation across methods and hyperparameters
- Conducted rigorous multi-seed evaluations with policy checkpointing, demonstrating smooth and reliable convergence to optimal performance, for REINFORCE with Baseline and A2C (N=10, 100), in under 300 episodes

Retrieval-Augmented Generation (RAG) for Question Answering Apr 2025

- Built a question-answering system that combines semantic retrieval with LLMs to extract answers from long documents
- Designed a RAG system with Sentence-BERT to embed text chunks and retrieve top results using similarity search
- Deployed local inference using Hugging Face Transformers (Gemma-2B-IT), applying multi-shot prompting to enhance coherence and depth of generated answers
- Adapted LLMs to domain-specific data using Hugging Face PEFT and LoRA on a RAFT dataset using minimal parameter tuning

Transformer-Based PDE Sequence Prediction Apr 2025

- Modeled nonlinear PDE (Burgers' equation) with decoder-only Transformer for autoregressive prediction of spatiotemporal states
- Implemented scaled dot-product and multi-head attention mechanisms, validating architecture through output comparison
- Integrated sinusoidal positional encoding, causal self-attention, and relative L2 loss for dynamics learning
- Achieved low autoregressive loss (near 0.077) over 50 epochs and visualized predication fidelity to support sequence modelling

Photometric Stereo for 3D Surface Reconstruction Apr 2025

- Executed calibrated photometric stereo to estimate surface normals and albedos from multi-illumination facial images using matrix factorization and pseudonormal recovery, enabling detailed surface reconstruction from shading cues
- Refined normal fields using integrability constraints and reconstructed depth maps via Frankot-Chellappa integration
- Extended the method to uncalibrated stereo by applying SVD-based factorization to image intensity data, estimating lighting directions and surface shape in the absence of known illumination conditions
- Visualized depth surfaces under varying bas-relief transformations, analyzing effects of ambiguity parameters on perceived geometry

Autonomous Vehicle Control Oct 2024 - Dec 2024

- Simulated full-stack autonomous driving behavior for a Tesla Model 3 in Webots using custom vehicle dynamics and control modules
- Modeled linearized bicycle dynamics to design PID controllers for real-time lateral and longitudinal trajectory tracking
- Implemented state-space control via pole placement for improved stability and responsiveness under curvature variations
- Developed discrete-time LQR controller to optimize lateral steering performance under noisy conditions and road constraints
- Programmed A* path planning for real-time obstacle-aware trajectory generation and safe local navigation
- Deployed EKF-SLAM to estimate vehicle position and heading in GPS-denied environments, leveraging sensor noise modeling and range/bearing measurements to enhance localization accuracy

Continuous Variable Transmission Bicycle Aug 2024 – Dec 2024

- Architected the control system for a CVT bicycle by designing the electrical subsystem and implementing a PID-based feedback loop using encoder data to position the belt in real time, enabling seamless manual gear ratio change based on user input via potentiometer
- Showcased a fully functional CVT bicycle prototype with smooth manual shifting, validated through real-world testing
- Incorporated IMU-based velocity and inclination sensing to support future development of an automatic gear-shifting mechanism

SKILLS

Programming Languages: Advance - Python, MATLAB; Intermediate - C++, C
Platforms & Tools: Docker, Git, Linux, Isaac Lab, Isaac Sim, ROS2, Arduino, Webots, OpenFOAM, AutoCAD, Fusion360, SolidWorks
Frameworks & Libraries: PyTorch, Gym, OpenCV, NumPy, SciPy

ACTIVITIES

- Supporting 80 students as a Teaching Assistant for CMU's '24-677 Modern Control Theory' course for Fall 2025
- Supported 30 students as a Grader for CMU's '24-703 Numerical Methods' course for Spring 2025
- Awarded Best Overall Project for CVT Bicycle at CMU Mechanical Engineering Design Expo, Fall 2024