Krishi Attri

krishiattriwork@gmail.com · krishi-attri15 · Archerkattri · archerkattri.github.io
ORCID: 0009-0005-4695-6467

Research Profile

Robotics researcher admitted to the Ph.D. programme at the University of Central Florida (Rehabilitation Engineering & Assistive Device Lab), currently completing an M.S. in Mechanical Engineering at Seoul National University under a Government Science Fellowship (GSFS). My research focuses on **online 3D reconstruction and pose tracking for robotic manipulation**, specifically developing visuo-tactile SLAM systems built around explicit **3D Gaussian Splatting** representations that enable robots to reconstruct and track objects under heavy occlusion during in-hand manipulation.

I am currently developing and integrating these systems as part of a humanoid robot project at the lab, fusing multimodal perception—RGB-D vision, DIGIT tactile sensing, and hand proprioception—into a shared Gaussian object state that simultaneously supports reconstruction, pose tracking, and manipulation interfaces. In parallel, I build and maintain open-source research software released on PyPI with archived DOIs: HiCache++, a training-free DMD velocity-cache that accelerates diffusion- and flow-based image-to-3D models; splatreg, a Gaussian-splat registration library; mathlas, a formal-math MCP toolkit for AI agents; and CERT-FLOW, a certified route planner under drifting costs. My work spans GPU-accelerated algorithm development, multimodal sensor fusion, and full-stack hardware–software integration on platforms including the UR5e and Allegro Hand.

Education

Ph.D., Mechanical Engineering — Post Master's Track *Aug 2026 (Incoming)*
University of Central Florida | *ORCGS Doctoral Fellow* | *Rehabilitation Engineering & Assistive Device Lab (REAL)* | *Advisor: Professor Hwan Choi* *Orlando, FL, USA*

Master of Science in Mechanical Engineering *Sept 2024 – Aug 2026 (Expected)*
Seoul National University | *GSFS Scholar* | *Soft Robotics & Bionics Laboratory* *Seoul, South Korea*

Bachelor of Science in Mechanical Engineering *Aug 2020 – May 2024*
Villanova University | *Minor in Mechatronics* | *Control & Dynamics* Diploma *Villanova, PA, USA*

Exchange Student — B.S. Mechanical Engineering *Aug 2022 – June 2023*
Yonsei University *Seoul, South Korea*

Research Experience

Graduate Research Student *Sept 2024 – Aug 2026*
Soft Robotics & Bionics Laboratory, Seoul National University *Seoul, South Korea*
Humanoid Robot Project — "Alchemist" Project (MOTIE, Republic of Korea; Phase 2)

- Contributing to **Phase 2 (2024–2026)** of the "Alchemist" Project — Korea's national high-risk, high-reward R&D program (MOTIE; Phase 1 completed 2024) — at the Soft Robotics & Bionics Lab.
- Leading integration of visuo-tactile SLAM and dexterous in-hand manipulation modules into the Phase 2 full-scale humanoid prototype.

- Coordinating cross-disciplinary teams to hit quarterly hardware–software integration milestones.

GaussianFeels: Object-Centric Gaussian SLAM for Visuo-Tactile In-Hand Manipulation (M.S. Thesis)
Advisor: Professor Yong-Lae Park, Seoul National University

- Developed GaussianFeels: an online visuo-tactile reconstruction and 6-DoF pose-tracking system built around an explicit object-centric 3D Gaussian Splatting map for robotic in-hand manipulation under heavy occlusion — no CAD model required.
- Fuses RGB-D vision, DIGIT tactile contact geometry, and hand proprioception into a single Gaussian object state maintained online, with occlusion-aware multimodal supervision and a SLAM-loop SE(3) pose tracker; reconstruction is seeded at frame 0 by an image-to-3D generative shape prior that is progressively replaced by measured geometry.
- Evaluated on the FeelSight benchmark family (14-object sweep) across simulation, real-world robot rollouts, and occlusion-focused episodes, benchmarked against the NeuralFeels and V-HOP baselines.
- **Results:** median ADD-S of 0.83 mm (simulation) and 3.37 mm (real) at ≈28 and ≈23.5 FPS on a single RTX 5090; retains 94% of simulation reconstruction F-score@5 mm on real hardware (0.95→0.89) versus 80% for NeuralFeels; matches or exceeds the model-free NeuralFeels baseline at ≈7.6× the frame rate with no supplied CAD model.

PoP-SLAM: Point Cloud Projection for SLAM Paper
Co-authors: Seongmin Jung (SNU AI), Josselin Marchand (École des Mines), Michele Lorenzo Paolicchi (Vrije Universiteit Amsterdam)

- Co-developed PoP-SLAM: a dense visual SLAM system that introduces a projection-first rendering strategy, eliminating computationally intensive nearest-neighbor searches inherent to neural point cloud-based SLAM.
- Designed GPU-vectorised point cloud projection: transforms up to ∼15 000 neural points per frame into image space using vectorised matrix multiplication, enabling real-time SLAM at ∼**4 FPS**.
- Introduced direct occlusion detection via multi-keyframe depth masking: projects neural points to nearby keyframes and retains only points consistent with measured depth across all keyframes, avoiding volume rendering entirely.
- Achieved **best ATE RMSE of 0.75 cm** on TUM-RGBD dataset, outperforming Point-SLAM, NICE-SLAM, ESLAM, and SplaTAM; competitive 0.38 cm average on Replica dataset.
- Evaluated on synthetic (Replica) and real-world (TUM-RGBD) benchmarks; demonstrated robustness across varied indoor scenes.

Undergraduate Research Intern (Winter Internship) *January 2024*
Soft Robotics & Bionics Lab, Dept. of Mechanical Engineering, Seoul National University Letter *Seoul, South Korea*

- Participated in a team project developing a surface electromyography (sEMG) sensor with flexible design elements for enhanced wearability and adaptability.
- Contributed to research on improving sensor stretchability through PDMS (polydimethylsiloxane) and vapour-deposited silver nanoparticles.
- Assisted in applying deep learning models (CNN-GRU, CNN-RNN, ViT) to sEMG signal processing, contributing to efforts to reduce classification error and improve gesture-recognition accuracy.
- Gained proficiency in ML-based signal processing and collaborated with a team of engineers to meet project milestones.

Robotics & Mechatronics Researcher *Aug 2023 – May 2024*
Villanova University EOD robot Drone *Villanova, PA, USA*

- Collaborated with a Ph.D. candidate on a dissertation titled "Autonomous Localisation and Navigation in GNSS-Denied Environments," advancing SLAM algorithms via LiDAR–camera fusion and visual odometry for a quad-wheel robot.
- Developed a full ROS-based navigation stack for the robot, implementing path planning and obstacle-avoidance algorithms.
- Applied CNN-based feature extraction and point cloud generation from fused LiDAR–camera data to

support autonomous decision-making without GPS.
- Integrated and configured Arduino and Raspberry Pi microcontrollers for robust ROS communication and real-time control.
- Implemented computer vision techniques (edge detection, landmark identification) to build real-time 3D environment maps.
- Implemented a 2D histogram localisation filter and a 1D Kalman filter tracker using probabilistic motion models for improved tracking accuracy.

Publications & Software

Theses, Papers & Preprints

- **GaussianFeels: Object-Centric Gaussian SLAM for Visuo-Tactile In-Hand Manipulation. K. Attri.** M.S. Dissertation, Seoul National University, Aug 2026. *(Thesis & code release upcoming.)*
- **CERT: Certified Route Planning under Drifting Costs — Conformal Certificates, Sense-to-Certify, and the Price of Staleness. K. Attri.** Preprint, 2026 (solo author; companion software: CERT-FLOW).
- **PoP-SLAM: Point Cloud Projection for SLAM.** S. Jung, **K. Attri**, J. Marchand, M. L. Paolicchi. Course research paper, Seoul National University, Dec 2024. Paper

Open-Source Software (PyPI releases with archived DOIs)

- **splatreg** — Gaussian-splat registration & merging. DOI: 10.5281/zenodo.20618389 PyPI
- **mathlas** — airtight-math MCP toolkit for AI agents. DOI: 10.5281/zenodo.20618603 PyPI
- **HiCache++** — training-free diffusion/flow sampler acceleration. DOI: 10.5281/zenodo.20618824 PyPI
- **CERT-FLOW** — certified route planning under drifting costs. DOI: 10.5281/zenodo.20631475 PyPI

Professional Experience

Indoor Farm Robotics Intern
June 2023 – Aug 2023

Area2Farms SILO demo — *Arlington, VA, USA*

- Contributed to the "Silo" automation tool for the local food system supply chain.
- Gained hands-on experience in extruded aluminium construction, pneumatics, industrial robotics, Arduino/Raspberry Pi programming, and agricultural irrigation systems.
- Collaborated with a cross-functional team to prototype automation solutions for indoor vertical farming.

Product Design Intern
June 2022 – Aug 2022

Ampere LLC (Remote) Certificate — *Virtual, USA*

- Contributed to 3D product modelling for upcoming consumer-technology designs, including **Shower Power** and an upcoming iPhone charging product.
- Analysed structural integrity and physics constraints to ensure product performance and durability.

Distance Education Operator
Sept 2021 – Dec 2021 & Aug 2023 – May 2024

Villanova University — *Villanova, PA, USA*

- Provided technical support for audio/video systems used in online course production.
- Managed live-stream recording and archiving of Distance Education materials for course content reliability.

Collections & Stewardship Technician
Jan 2022 – May 2022

Villanova University — *Villanova, PA, USA*

- Produced digital content for the university Digital Library using scanners, digital cameras, and archiving software.
- Managed records in cataloguing and acquisitions software; supported preservation of rare and special

collections materials.
- Labelled and physically prepared new and rare library materials, and coordinated binding/repair shipments of books, periodicals, and theses.

Research Projects

GaussianFeels: Object-Centric Gaussian SLAM for Visuo-Tactile In-Hand Manipulation (M.S. Thesis) *Dec 2024 – Present*

Objective: Achieve robust in-hand object reconstruction and pose tracking under heavy occlusion by fusing RGB-D vision, DIGIT tactile sensing, and hand proprioception into a shared object-centric 3D Gaussian Splatting representation.

- **Approach:** Object-centric Gaussian map updated online from RGB-D, DIGIT tactile, and proprioceptive observations; occlusion-aware multimodal supervision; SLAM-loop SE(3) pose tracking (multi-residual Levenberg–Marquardt over a Gaussian-density SDF); frame-0 image-to-3D shape prior progressively replaced by measured geometry.
- **Evaluation:** FeelSight benchmark family (14-object sweep) — simulation, real-world rollouts, and occlusion-focused variants; benchmarked against NeuralFeels and V-HOP. Median ADD-S 0.83 mm (sim) / 3.37 mm (real) at ≈28 / ≈23.5 FPS on one RTX 5090; 94% sim-to-real F-score@5 mm retention versus 80% for NeuralFeels; ≈7.6× NeuralFeels throughput with no supplied CAD model.

PoP-SLAM: Point Cloud Projection for SLAM (Seongmin Jung, Krishi Attri, Josselin Marchand, Michele Lorenzo Paolicchi) Paper *Sept 2024 – Dec 2024*

- **Innovation:** Projection-first rendering pipeline projecting ∼15 000 learned neural points/frame on GPU via vectorised matrix multiplication — no nearest-neighbor search required.
- **Occlusion Handling:** Multi-keyframe depth masking selects only points consistent with measured depth across nearby keyframes — no volume rendering required.
- **Tracking Accuracy:** ATE RMSE 0.75 cm on TUM-RGBD (best among all evaluated methods including Point-SLAM, NICE-SLAM, ESLAM, SplaTAM); 0.38 cm average on Replica.
- **Speed:** ∼4 FPS on NVIDIA RTX 4070 (3× faster than Point-SLAM baseline); <3.3% overhead from point pruning.
- **Datasets:** TUM-RGBD (fr1-desk, fr1-room, fr2-xyz, fr3-office) and Replica (synthetic indoor scenes).

HiCache++: Training-Free DMD Velocity-Cache for Diffusion & Flow-Based 3D Generation PyPI *2026*

- Designed **HiCache++**, a model-agnostic, training-free DMD / exponential velocity-cache that skips redundant denoising compute in diffusion and flow samplers while preserving output fidelity — on Hunyuan3D-2.1 it holds reconstruction F-score where the polynomial basis collapses (0.86 vs 0.74 at skip-interval 5), extending the lossless skip range of the prior HiCache (Hermite) and TaylorSeer lines.
- Built and benchmarked acceleration across six production image-to-3D and generative backbones — Hunyuan3D-2 mini, Hunyuan3D-2.1, TRELLIS v1 and TRELLIS.2-4B, Meta SAM 3D Objects, Fast-SAM3D, and DiT-XL/2 (ImageNet) — via a **14-repository adapter family** (including a ComfyUI node), benchmarked against the HiCache and TaylorSeer baselines; geometry-lossless (F1 = 1.000) to skip-interval 6 at 1.56× on SAM 3D Objects; training-free holdout auto-selector detects basis misfit 120/120.
- Released open source (Python; MIT) with PyPI package and archived DOI; directly accelerates the Hunyuan3D image-to-3D prior used by the GaussianFeels frame-0 reconstruction branch.

splatreg & mathlas: Open-Source Research Tools *2026*

- **splatreg** GitHub PyPI — a pure-PyTorch library that registers and merges native 3D Gaussian-Splatting scans into one SE(3)/Sim(3) frame via a closed-form-Jacobian Gaussian-SDF residual; matches GeoTransformer on official 3DMatch (91.5% recall) while adding the Sim(3) scale DoF it lacks, and reaches ADD-S AUC 0.995 on YCB object pose at ∼17 ms.
- **mathlas** GitHub PyPI — an "airtight-math" MCP toolkit (12 LLM-free, data-returning tools) giving AI

agents a 3.68M-document theorem search (dual-channel R@10 0.999), PSLQ/OEIS constant & sequence identification, and Lean-kernel formal verification (full proof checking) at a 0% measured false-positive rate; its self-augmenting retrieval loop surpasses TheoremSearch on its own 110-query benchmark (59.1% vs 45.0% Hit@20); listed on the official MCP registry.

CERT-FLOW: Certified Route Planning under Drifting Costs PyPI *2026*

- Designed and built a planner that emits a high-probability certificate $LB \leq OPT \leq UB$ on optimal route cost every replanning round — age-weighted non-exchangeable conformal prediction over drift-adjusted residuals, with paid sensing directed at the edges that shrink the certified gap fastest.
- Backed by seven theorems (coverage with explicit staleness degradation, a certifiability threshold, and an impossibility result); coverage 0.95–1.00 on every condition run — 17 synthetic regimes, game maps, and replayed real traffic (METR-LA, PEMS-BAY) at up to 49% drift-model violation — versus 0.02–0.59 for classical replanning.
- 2–3$\times$ lower travel-regret than freshness-, uncertainty-, or chance-driven sensing at equal budget; 3.7 ms p50 per fully certified round on one CPU core, with certificate-gated static queries in 269 ns–8.7 μs; 227 tests and 16 scripted reproduction pipelines.
- Solo-author preprint (*CERT: Certified Route Planning under Drifting Costs*, 2026) with open-source MIT package on PyPI + archived DOI.

Personal & Course Projects

Computer Vision Object Detection Web Application *Summer 2024*

- Built a full-stack web application for real-time image and video object detection using a React frontend and Flask backend.
- Implemented and benchmarked five detection models: Faster R-CNN, Mask R-CNN, RetinaNet, Keypoint R-CNN, and SSDlite using PyTorch and TensorFlow with COCO dataset evaluation. Key findings: Mask R-CNN achieved highest annotation confidence (>0.8 scores); SSDlite fastest throughput; Faster R-CNN balanced both.
- Evolved through 8 development versions: from single-model photo processing through modularisation to multi-model video comparison, with an in-development custom "Focus Auto-Population Scan" model.
- Stack: Python (62%), JavaScript (23%), CSS (13%), HTML (1%).

Capstone: Plant Lifting Device for 3D Imaging Demo Award Photos *Aug 2023 – May 2024*

*Sponsored by a major agrochemical company — **1st Place, Most Innovative Solution***

- Led a multidisciplinary team through the full design-to-prototype lifecycle: actuator selection, motion system (belts, pulleys, drive gears), wiring, waterproofing, and plant platform engineering.
- Addressed sponsor constraints (strict size limits), plant stability risks, and motor-damage risks by developing a stabilising platform and controlled-speed mechanism.
- Applied project management across all design phases; awarded first place for Most Innovative Solution at the university capstone showcase.

Arduino Projects — Mechatronics Coursework *Jan 2022 – May 2022*

- Designed and built three Arduino-based projects integrating pressure, photo, and sound sensors with actuators, motors, and LCD displays.
- Notable project: a puzzle box that randomised solution steps via algorithm and deployed a glitter-spray penalty for incorrect sequences.

Beetle-Bot — Miniature Combat Robot Photo *Aug 2021 – Dec 2021*

- Collaborated in a four-member team to build a miniature combat robot from scratch; achieved 3rd place among sophomore Mechanical Engineering students.

Previous Personal Projects Photos *Summer 2021*

- **Wi-Fi Drone:** Designed and programmed a Wi-Fi-controlled drone with custom stability logic.
- **Swarm Drones:** Developed multi-drone coordination algorithms for communication and synchronisation.
- **Robotic Arm:** Built a servo-actuated robotic arm programmed for pick-and-place operations.
- **3D Printer:** Assembled a 3D printer from scratch including hardware build and slicing software configuration.

SOLIDWORKS Project — Functional Scooter Model *Jan 2021 – May 2021*

- Completed SOLIDWORKS coursework; collaborated in a four-member team to design and 3D-print a functional scooter model.

AI Mini-Project — Basketball Outcome Prediction *Aug 2020 – Dec 2020*

- Explored ML fundamentals in Python; collaborated in a three-member team to build a predictive model for basketball game outcomes.

ICE Competition — Assistive Device for the Visually Impaired *Aug 2020 – Dec 2020*
*Innovation, Creativity & Entrepreneurship Competition (IIE Idea Challenge) — **3rd Place, College of Engineering***

- Led ideation and business model development in a four-member team, designing a wearable assistive device to aid visually impaired individuals.

Technical Skills

SLAM & 3D Reconstruction

- 3D Gaussian Splatting, Visuo-Tactile SLAM (GaussianFeels), Neural Point Cloud SLAM (PoP-SLAM)
- Point Clouds, Structure from Motion (SfM), RGB-D Reconstruction, Object-Centric Gaussian Mapping
- Contact-aware Gaussian population management, occlusion-aware multimodal supervision, Levenberg–Marquardt SE(3) optimisation, gsplat
- SLAM benchmarking (TUM-RGBD, Replica datasets)
- Point-cloud & Gaussian-splat registration: SE(3)/Sim(3), Gaussian-SDF residual, ICP, FPFH+RANSAC, GeoTransformer (3DMatch / 3DLoMatch); splatreg

Deep Learning & AI

- PyTorch, TensorFlow, NVIDIA CUDA (custom kernel development)
- Multimodal Learning, Differentiable Rendering
- CNN, RNN, CNN-GRU, CNN-RNN, Vision Transformer (ViT)
- ML for signal processing and predictive analytics
- Reproducible ML workflows, experiment pipeline design, model orchestration
- Ollama (local LLM inference), Genesis (robotics simulation)

Generative 3D & Diffusion Acceleration

- Training-free sampler acceleration: **HiCache++** (DMD / exponential velocity caching); HiCache (Hermite feature caching), TaylorSeer
- Image-to-3D & 3D generative models: Hunyuan3D-2 / 2.1, TRELLIS v1 / v2, Meta SAM 3D, Fast-SAM3D, DiT
- 3D Gaussian Splatting registration & merging (splatreg), gsplat
- Spectral forecasting: Dynamic Mode Decomposition (DMD / Prony / Matrix-Pencil)

AI Agents, Retrieval & Formal Methods

- MCP (Model Context Protocol) tool & server development for AI agents (mathlas)
- Dense & hybrid retrieval: transformer embeddings (Qwen3), BM25, reciprocal-rank fusion
- Formal & numeric verification: Lean 4 kernel, PSLQ, OEIS, high-precision (mpmath) identification
- Uncertainty quantification & certified planning: non-exchangeable conformal prediction, incremental

search (D* Lite), certificate-directed sensing (CERT-FLOW)
- Program synthesis / evolutionary search (FunSearch), sandboxed evaluation

Robotics & Middleware
- ROS, OpenCV, Open3D, COCO API
- Sensor Fusion, Real-time Inference, Path Planning, Autonomous Navigation
- Simulation & Sim-to-Real: NVIDIA Omniverse → UR5e + Allegro Hand
- Robot hardware/software integration (perception ↔ actuation APIs)

Hardware & Sensors
- DIGIT Visuo-Tactile Sensor, RGB/RGB-D Cameras, LiDAR (camera fusion)
- VectorNav IMU, Emlid RTK GPS, NVIDIA GPUs
- UR5e Robotic Arm, Allegro Hand, Raspberry Pi / Teensy / Arduino
- 3D Motion Capture (Vicon/OptiTrack)
- 3D Modelling & Printing, Machine Shop Tools

Programming Languages
- Python, C/C++, CUDA, MATLAB, Arduino, LaTeX, HTML, Django, MySQL, VHDL, Maple

Software & Tools
- Simulation & CAD: NVIDIA Omniverse, SOLIDWORKS, Blender, KiCAD
- Dev Tools: Git/GitHub, Jupyter Notebooks, Anaconda, Linux (Ubuntu), PowerShell
- Web: React.js, Flask
- Office & Misc: Microsoft Office, Matplotlib, Sklearn

Languages
- English (Fluent), Hindi (Fluent), Korean (Beginner)

Certifications, Licenses & Awards

NVIDIA Computer Vision Nanodegree *Winter 2024*
Udacity in partnership with NVIDIA

- Modules: Introduction to Computer Vision, Advanced CV & Deep Learning, Object Tracking & Localisation, Cloud Computing, Neural Network Training, C++ Programming, Applied Deep Learning Projects.

Innovative Robot Technologies and their Applications Certificate *Aug 2024*
K-MOOC × Seoul National University Credential ID: c65ee02c32ee88873985a799fab29ef8

GRE General Test Report *Sept 2023*
Credential ID: 82736046 Blockchain ID: 809252

- Verbal Reasoning: 153 (56th percentile)
- Quantitative Reasoning: 166 (80th percentile)
- Analytical Writing: 4.0 (56th percentile)

Capstone Project — 1st Place, Most Innovative Solution Award *May 2024*
Villanova University Capstone Showcase (Industry-Sponsored)

ICE Competition — 3rd Place *Dec 2020*
Innovation, Creativity & Entrepreneurship Competition, College of Engineering

Beetle-Bot Competition — 3rd Place *Dec 2021*
Villanova University Mechatronics Course

Dean's List Proof *Fall 2020, Spring 2021*
Villanova University

UPenn Robotics Specialisation *Summer 2021*

Coursera in partnership with University of Pennsylvania

- Aerial Robotics, Computational Motion Planning, Mobility, Perception, Estimation and Learning, Capstone.

Relevant Coursework

Seoul National University

- Deep Learning
- Topics in Control and Automation
- Smart Materials and Design
- Precision Metrology and Vision Inspection
- Control Systems 1
- Engineering Research Ethics and Writing Skills
- TA: Mechanical Product Design

Villanova University

- Computer Programming for Mechanical Engineering
- Mechatronics & Microcontrollers and Applications
- Dynamic Systems I & Lab
- Capstone Design I & II
- ME Undergraduate Research I
- Manufacturing Engineering
- Mechanics of Materials / Solid Mechanics & Design I
- Electrical Circuit Fundamentals
- Material Science I
- Thermodynamics
- Engineering Interdisciplinary Project I
- Intro to Computer-Aided Design & Craft (SOLIDWORKS)
- Statics; M.E. Analysis & Design; ME Laboratory II
- Fundamentals of Computer Programming Engineering I & Lab

Yonsei University (Exchange)

- Heat Transfer, Fluid Mechanics, Mechanical Vibrations, Mechanical Systems Control, Basic Circuit Theory, Probability and Random Variables

Leadership & Activities

Secretary *May 2021 – May 2023*
Villanova CubeSat Club *Villanova University*

- Fostered community engagement in space science with a focus on CubeSats.

Representative & Head of Special Events *Aug 2020 – Aug 2022*
Villanova International Students' Organisation (VISO) Certificate *Villanova University*

- Built connections between upperclassmen and incoming international first-year students; organised social events to strengthen community.

Member *May 2021 – Aug 2022*
Society of Asian Scientists and Engineers (SASE) *Villanova University*

- Supported SASE's mission of preparing Asian-heritage scientists and engineers for the global business landscape.

Member *May 2021 – Aug 2022*

American Society of Mechanical Engineers (ASME) *Villanova University*

- Contributed to professional development activities and chapter engineering initiatives.