Aayush Dulal

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EDUCATION

The University of Texas at Dallas, Ph.D. Mechanical Engineering 2024–Present
Courses: Linear Systems, Non-linear Systems, Engineering Optimization, Artificial Intelligence, Robotics, Multi-agent Robotics **CGPA 3.953 / 4.0**

Tribhuvan University, B.E. Mechanical Engineering 2022
Courses: Engineering Mathematics, Control Systems, Theory of Machines, Numerical Methods, Probability and Statistics **CGPA 75.45 / 100**

SKILLS

Programming: C++, Python, MATLAB, Simulink
Robotics & Simulation: ROS, ROS2 Control, Gazebo, Isaac Lab, MoveIt
Modeling & Analysis: SolidWorks, ANSYS
Prototyping & Design: PrusaSlicer, Inkscape

WORK EXPERIENCE

Graduate Research Assistant, The University of Texas at Dallas Aug 2024–Present
Graduate Research Assistant, Northern Arizona University Jan 2024–May 2024
Research and Development Engineer, Robotics Association of Nepal Feb 2023–Dec 2023

- **Seed Bombing Drone Payload Development:** Led the mechanical engineering effort to design and fabricate a custom payload and release mechanism for a **DJI Matrice 300**, enabling controlled deployment of up to **200 seed bombs**
- Performed detailed solid modeling in **SolidWorks** and conducted aero-dynamic analysis in **ANSYS** to validate structural integrity and flight compatibility
- Oversaw fabrication of the payload housing and 3D-printed custom drone attachments, and coordinated closely with the electrical engineering team on **custom PCB design and fabrication**
- Implemented low-level firing and actuation logic on an **STM32 microcontroller**, integrating custom release and drop mechanisms for reliable deployment.
- **Flood Early Warning System Development:** Led machine learning development for a **real-time flood early warning system** deployed along the Kamala River in Nepal
- Evaluated time-series forecasting approaches, including **SARIMA**, and identified a **linear regression model** with river height lag features as the most robust predictor
- Performed feature analysis to determine lagged river height measurements as the most influential inputs for short-horizon flood prediction
- Oversaw mechanical fabrication of the system housing and supervised on-site deployment and installation of the monitoring system

RESEARCH EXPERIENCE

Exact Representation of Explicit Model Predictive Control Laws with ReLU Neural Networks *(2024–Present)*

- Developed an algorithm to convert piecewise-affine explicit MPC laws for linear systems with polyhedral constraints into **exact ReLU neural network representations** with analytically derived weights and biases
- Achieved significant reductions in **storage requirements and online evaluation complexity** without any network training
- Enabled compact deployment of explicit MPC controllers using structured neural representations that require **NO TRAINING**.

Exact Representation Complexity Reduction for Constrained Zonotopes *(2024–Present)*

- Developed an algorithm for **exact complexity reduction of constrained zonotopes** while preserving full set equivalence
- The composite algorithm is capable of removing different forms of redundancy in constrained zonotopes and provides a practical balance between computational efficiency and the achieved reduction in representation complexity
- Demonstrated effectiveness on the evaluation of robust controllable sets and polyhedral partitions arising from ReLU neural network decision regions

Bi-Fidelity Transfer Learning of Bayesian Neural Networks *(2024)*

- Implemented multiple transfer learning strategies for Bayesian neural networks trained on bi-fidelity datasets
- Applied to vehicle suspension modeling with uncertainty quantification to support robust model development

Fuzzy Logic Controller for a 3-DOF Robot Manipulator *(2021–2022)*

- Designed and simulated a fuzzy logic controller (FLC) incorporating joint acceleration as an additional input
- Designed and simulated a PID controller and made comparisons with the FLC.
- Deployed and validated the controller in Gazebo using ROS

Optimal EV Charging Station Placement in Kathmandu Valley *(2022–2023)*

- Formulated and solved a **Mixed-Integer Linear Program (MILP)** using the CPLEX Python API
- Identified optimal charging station locations under infrastructure and demand constraints

PROJECTS

Learning-Based Manipulation with Hybrid Imitation and Reinforcement Learning

- Developed a learning-based manipulation pipeline on the **SO101 robotic arm** using a hybrid imitation learning and reinforcement learning framework for language-conditioned pick-and-place tasks on real hardware
- Fine-tuned the **SMOLVLA vision-language-action model** via imitation learning using **90 real-world demonstration episodes** to obtain a safe and task-relevant initial policy
- Initialized reinforcement learning from the imitation policy to improve robustness and task success while constraining exploration around expert-like actions
- Deployed the system achieves **seventy** percent accuracy using only an end-effector-mounted camera, resulting in frame-to-frame input variation and observable motion jitter due to the absence of a stable top-down view

Online Model Predictive Control for 3D Drone Trajectory Planning Online Nonlinear Model Predictive Control for Drone Trajectory Planning

- Formulated drone navigation as an online **nonlinear MPC** problem solved with **MATLAB fmincon (SQP)**, optimizing acceleration and yaw rate commands under nonlinear dynamics, actuator limits, energy usage, and obstacle avoidance constraints
- Enforced collision avoidance using smooth nonlinear inequality constraints from **circular no-fly zones** derived from real neighborhood maps, enabling smooth, collision-free trajectories through dense environments with warm-started optimization over a horizon of **N = 15**

ROS2-Based Manipulation Control and Planning Simulation

- Developed robot manipulation controllers using ROS2 control in Gazebo and integrated MoveIt for motion planning and execution.

Binary Gender Classification Using Computer Vision

- Implemented face detection using OpenCV Haar cascades and performed binary gender classification using a ResNet-based convolutional neural network.

PUBLICATIONS

Dulal, A., Koeln, J. (2026). *Exact Representation Complexity Reduction for Constrained Zonotopes with Applications to Dynamic Systems and Control*. American Control Conference (ACC) — *under review*

Rana, L., **Dulal, A.** (2025). *Wi-Fi RSS and RTT Indoor Positioning with Graph Temporal Convolution Network*. Sensors, Issue 24

Ghimire, S., **Dulal, A.**, Rawal, K. (2022). *Comparison of New Fuzzy Logic Controller Algorithm and Classical PID Controller for Trajectory Tracking*. XVII VETOMACC — *under review*

Shrestha, S., **Dulal, A.**, et al. (2025). *Drone-Based Seed Bombing Mechanism for Ecological Restoration*. ICICSET

Shrestha, S., **Dulal, A.**, et al. (2025). *AI-Based Flood Early Warning System for Terai Rivers in Nepal*. International Conference on ICT and Photonics