Adnan Amir

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Education

Northeastern University, Boston, MA — Dec **2025**
Master of Science in Robotics (Mechanical Concentration)
Relevant Coursework: Robot Sensing & Navigation, Control Systems, Mobile Robotics, Pattern Recognition & Computer Vision

NMIMS University, Mumbai, India — **Jul 2023**
Bachelors of Technology (Honours) in Mechatronics with minor in Robotics and IoT
Relevant Coursework: Robot System Design, Mechatronics System Design, Control Systems

Skills

Languages: Python, C++, MATLAB, C, LabView (VI), Inform III, PLC Ladder Logic
Software: Fusion360, SolidWorks, LabVIEW, Proteus (PCB Design), Gazebo, Simulink, Coppeliasim
Tools & Libraries: ROS(middleware), OMPL, Pandas, Ceres, TensorFlow, QT creator, Orocos-KDL, cvxpy, Linux, Git, Eigen, OpenCV, Jax, NI DAQ
Soft Skills: Team Leadership, Public Speaking, Communication skills, Critical Thinking, Cognitive Flexibility, Detail-Oriented

Experience

Institute for Experiential Robotics - Northeastern University — **Sep 2024 – Dec 2025**
Graduate Research Engineer

- Led development of three robotics projects: cold spray **digital twin,** saving $200K-1M in equipment costs, PARIS robot (E-Robot Prize Finalist) targeting 15% reduction in heating/cooling costs for 60% of MA building emissions, and fish tracking system achieving 93% detection accuracy for MIT Sea Grant
- Architected **GPU-accelerated** cold spray simulation (**NVIDIA Warp**) training PINN surrogate models for non-linear deposition, replacing $60/lb material testing with synthetic data generation. Implemented **HIL simulation** using **Isaac Sim + ROS2** bridge for real robot trajectory capture and SDF-based deposition analysis achieving 1.3ms inference; 100x faster than Fast Point Transformer
- Deployed **Unitree Go2 + Kinova** platform with thermal/visual fusion for hotspot mapping, **PointSLAM+nvblox** for 3D reconstruction, and cuMotion for confined space manipulation under $10K target cost
- Extended autonomous fish localization framework with **RT-DETR**-based tracking using **PyTorch Lightning**, generating 20K+ synthetic training images via classical CV techniques and validating through weighted ensemble of **SuBSENSE, SUIM-Net, and RLOF** algorithms for robust underwater fish monitoring

Northeastern University — **Jan 2024 – Dec 2025**
Graduate Teaching Assistant, EECE 4649, 3468, 5666, 5626

- Taught numerical methods, probability/statistics, digital signal processing, and computer vision across 4 graduate/undergraduate courses, developing course materials in **MATLAB/Python** and conducting weekly office hours for 100+ students
- Delivered guest lecture on **statistical learning and random processes** in EECE 3468, covering applications in AI/ML, parameter estimation, and hypothesis testing with real-world engineering examples
- Guided students through complex implementations including **FFT algorithms, IIR/FIR filter design, image segmentation, pattern recognition** (Bayes classifiers), numerical optimization, and ODE solvers

Nordson Corporation — **May 2024 – Aug 2024**
Automation Engineer Intern

- Spearheaded the design and integration of a high-efficiency part-feeding subsystem using **SolidWorks**, Alan Bradley **PLC** on Rockwell Automation software, and Keyence for **machine vision** and safety, improving machine uptime by 60%
- Conducted system testing, troubleshooting, and optimization, collaborating with **cross-functional teams** to ensure compliance with industry standards, streamline processes, and accommodate **future enhancements**

Automata Systems — **May 2023 – Jul 2023**
Robotics Intern

- Developed standard documentation for using **EtherCAT** communication protocol with Raspberry Pi & Panasonic Drives by conducting thorough research and developed a document for the same to aid in company ISI mark application
- Designed and Implemented **RTOS firmware** for a real-time six axis robot controller using **C++** and EtherCAT communication protocol for testing on a robot arm hardware prototype which received a sponsorship for manufacturing

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LearnByResearch **Dec 2021 – Dec 2022**

MATLAB Researcher

- Devised the **control system** for an experimental **industrial robot arm** for strawberry harvesting using **MATLAB**, **Simulink & RoboAnalyzer** and made novel progress, publishing a research paper in an IEEE conference.
- Lead the research group of six, working in a cross functional team on the **SolidWorks** Model, **YOLO v3** based computer vision, Kinematic, Dynamic & Workspace Analysis**,** troubleshooting and root cause analysis of the issues in the project.

NMIMS Bosch Rexroth Centre of Automation **May 2022 – Jul 2022**

Robotics and Mechatronics Lab Intern

- Designed a **ROS**-based simulator for project and trajectory planning research on YASKAWA Motoman MH5. Deduced DH parameters for URDF creation & **kinematic modelling**
- Established SOP for **YASKAWA Motoman MH5** and **INFORM III** programming on a DX100 controller. Assisted in SOP creation for Pneumatics, Hydraulics, IoT, Universal **PLC** Kit, and CNC machining equipment

Verzeo **Feb 2021 – Apr 2021**

Robotics Intern

- Developed a line follower robot using Arduino, showcasing hardware design and programming expertise
- Designed and developed an animated obstacle-avoidance robot using Arduino to show embedded system expertise
- Designed and developed IoT PubSub system with MQTT protocol, showcasing scalable and interconnected system expertise

Projects

Cold Spray Digital Framework | Northeastern University **Sep 2024 – Dec 2025**

Developed a high-fidelity digital twin system for cold spray additive manufacturing using GPU-accelerated physics simulation and hardware-in-the-loop testing

- Built GPU-accelerated simulation framework in NVIDIA Warp to model non-linear cold spray deposition dynamics, generating synthetic training data that eliminates $60/lb material testing costs
- Trained Physics-Informed Neural Networks (PINNs) as surrogate models to capture complex deposition patterns beyond traditional Gaussian assumptions
- Implemented Hardware-in-the-Loop (HIL) simulation bridging Isaac Sim with real robot via ROS2, capturing actual robot dynamics for realistic trajectory planning and control
- Developed SDF-based real-time deposition analysis on GPU, computing target vs sprayed shape differences in 1.3ms (100x faster than Fast Point Transformer's 140ms)
- Achieved cost savings of $200K-1M in equipment costs by replacing physical testing infrastructure with single RTX 4070 GPU

Precise Air-Sealing Robot for Inaccessible Spaces (PARIS)| Northeastern University **Sep 2024 – Dec 2025**

Lead development of autonomous quadruped-manipulator system for confined space inspection and repair in construction retrofitting (E-Robot Prize Finalist)

- Integrated Unitree Go2 quadruped with Kinova Jaco manipulator for navigating attic crawlspaces and ceiling joists
- Implemented thermal/visual sensor fusion pipeline to generate hotspot maps for targeted air-sealing, addressing 60% of MA building emissions
- Deployed PointSLAM with nvblox for real-time 3D scene reconstruction and ICP for multi-sensor pointcloud fusion
- Developed ROS2 architecture for multi-modal sensor integration (LiDAR, depth cameras, IMU, thermal) and NVIDIA cuMotion for collision-free manipulation
- Designed system for sub-$10K commercial deployment, targeting 15% reduction in residential heating/cooling costs through automated air-sealing

Toolbox for Robust, Real-time, Automated FIsh Classification and Counting | MIT Sea Grant **Aug 2024 – Dec 2024**

Extended an autonomous fish localization framework by implementing tracking capabilities for real-time underwater species monitoring, achieving 93% detection accuracy for ecosystem management applications

- Implemented RT-DETR-based tracking module using PyTorch Lightning, advancing the system from localization-only to full tracking capability with 93% counting accuracy on real underwater footage
- Generated 20,000+ synthetic training images using classical computer vision techniques, varying fish position, orientation (front/side/tail views), shape, visibility, and underwater backgrounds
- Validated synthetic dataset through random sampling using existing weighted voting ensemble of SuBSENSE (background subtraction), SUIM-Net (semantic segmentation), and RLOF (optical flow) algorithms
- Integrated tracking module into three-phase TRRAFICC toolbox architecture (Localization, Tracking, Classification) for robust background-agnostic fish detection across diverse underwater environments
- Processed real underwater monitoring data from Massachusetts waterways (River Herring at Ipswich Mills Dam and luderick from Queensland estuaries) with varying turbidity and lighting conditions
- Collaborated with MIT Sea Grant researchers to develop scalable alternative to labor-intensive manual counting methods for long-term ecosystem studies and aquaculture management

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Robot Navigation with Reinforcement Learning | Northeastern University **Feb 2025 – May 2025**

Developed a custom simulation framework for training and evaluating reinforcement learning (RL) agents on robot navigation tasks in 2D environments with differential drive dynamics

- Built a vectorized gym environment with lidar sensing and random obstacle generation for diverse training conditions
- Implemented on-policy (PPO-CLIP, PPO-KL) and off-policy (SAC) RL algorithms
- Ablated SAC with critic architecture, adaptive entropy tuning for a deep study
- Enabled parallel training across multiple environments to boost sample efficiency and reduce convergence time.
- Improved Gym-trained models with Isaac-Sim for deployment, with model transfer and cross-platform evaluation

Bag of Visual Words (BoVW) Image Retrieval System | Independent Project **Jun 2024 – Aug 2024**

Built a full-stack C++ image retrieval pipeline using the Bag of Visual Words (BoVW) model for visual place recognition. Extracted SIFT features using OpenCV to capture local visual descriptors across a large image dataset.

- Created a visual vocabulary via K-means clustering, enabling compact image representation through histogram encoding
- Applied TF-IDF weighting to histograms to improve robustness and discrimination in high-dimensional visual space
- Implemented cosine similarity matching to rank database images by visual similarity to the query
- Created an HTML-based result visualizer to interactively explore retrieval output

Search and Rescue Robot | Northeastern University **Mar 2024 – May 2024**

Implementing MPPI-based exploration along with cartographer slam to detect April tags (victims) and using RL to optimize search on known map.

- Performing **extrinsic calibration** of 2D Lidar and Camera to mitigate noise in April tag estimated pose.
- Implementing Google's **cartographer SLAM** to build a map of the arena during exploration.
- Extending **MPPI** with inspiration from **frontier-based exploration** to get the bot to map the arena.
- Training an **RL** model using the map information to optimize search on subsequent missions.

Real-Time Augmented Reality (Hardware Project) | Northeastern University **Feb 2024 – Mar 2024**

Developed a program using OpenCV in C++ to project 3D objects on a chessboard and ArUco Board.

- Developed a chessboard and Aruco board **corner detection system** using some OpenCV functions to project images on.
- Implemented a feature to calculate **camera calibration parameters** in the system in real time. Achieved reprojection error below 0.2 pixels for an A4 size board.
- Estimated **camera pose** using **PnP algorithm** to facilitate drawing of 3D objects
- Added mini functionalities like hiding the board and an **obj parser** to project an obj file on the board.

Localization and Mapping from Scratch (Simulation Project) | Northeastern University **Feb 2024 – Mar 2024**

Implemented Monte Carlo Localization with a particle filter for position estimation on a predefined map and developed a log-odds mapping algorithm to create detailed maps using known robot positions in Python.

- Developed a **lidar measurement simulation** incorporating various noises to accurately mimic real-world lidar data.
- Utilized a **particle filter** to converge randomly initialized particles to the true position within a map for localization.
- Incorporated **encoder noise** in the self-derived motion model to emulate real sensor noise in the propagation step.
- Implemented an occupancy mapping algorithm by integrating a **log-odds technique**, compensating for all the noise.

Realtime Object Detection from Scratch (Hardware Project) | Northeastern University **Feb 2024 – Mar 2024**

Developed a C++ real-time object detection app using OpenCV and classical feature extraction, designed for dynamic learning and identification of objects through user inputs, enabling instant recognition in live feeds.

- Architected and implemented advanced image processing techniques, including **custom thresholding and morphological operations**, using OpenCV's Mat data structure to transform input images into binary format for further analysis.
- Designed and developed a **two-pass segmentation** algorithm for efficient segmentation of binary images into distinct regions, enhancing object detection accuracy.
- Innovated a feature extraction function to calculate critical **object attributes** (eccentricity, second moment, Hu moments) and integrated these features into a self-designed database for robust training and recognition processes.
- Employed **nearest neighbor** and **k-nearest neighbor** classification algorithms to achieve precise object classification, with real-time display of the identified object's label within the video feed.

Model Predictive Path Integral Controller (Simulation Project) | Northeastern University **Jan 2024 – Feb 2024**

Designed and implemented a controller using MPPI on a unicycle to drive at full speed around a noisy racetrack environment.

- Translated mathematics into functional code to design the unicycle model with imposed speed limits
- Experimented with and Tuned parameters such as **MPC** horizon and Number of rollouts to find the perfect balance of speed and computation
- Developed a **cost function** using distance to waypoints and map obstacle avoidance costs to select the best rollout
- Further improved the algorithm by removing waypoints and adding a goal position at the centre of the racetrack which was unreachable but the primitives were chosen in a way that the **shortest laps** were made at **full speeds**

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Content-Based Image Retrieval (Hardware Project) | Northeastern University **Jan 2024 – Feb 2024**

Developed a vision pipeline for Image Recognition using OpenCV in C++ and Various Image Processing techniques.

- Implemented a baseline **matching algorithm** which looked at a 7x7 grid in the middle of the image and extracted features to be used with **L2 norm** matching technique.
- Utilized **2D & 3D color and texture histogram**-based features combined with histogram intersection and **Bhattacharya distance** matching techniques to get improved matching.
- Integrated a **ResNet18 Neural Network** trained on the Imagenet Database to improve quality of features and matching.
- Designed a custom feature based on **HSV histogram, Gabor, Fourier transform** filters to rival the DNN matching.

Filtomatic: Real-Time Video Processing | Northeastern University **Dec 2023 – Jan 2024**

Developed and optimized a C++ program to implement real-time filters from scratch, including greyscale, sepia, blur and cartoonify, resulting in a 20% increase in processing speed compared to previous versions

- Integrated the **Haar Cascade** algorithm for face detection into the program, successfully detecting and tracking faces with an accuracy rate of 95%, improving overall performance by 15%
- Implemented advanced functionality to draw masks on detected faces in **real-time** using **OpenCV**, enhancing the user experience
- Integrated a meme generation function that allows users to make their own meme with the effects and save snippets

Lateral Path Tracking Controllers (Simulation Project) | Northeastern University **Oct 2023 – Jan 2024**

Tested out various robot control techniques on hand derived motion models and optimized them for best performance

- Developed **kinematic models** for a unicycle, simple car and differential drive, translating them into functional code.
- Successfully applied a **Pure Pursuit controller** to the unicycle model using Python, achieving a remarkable 100% success rate in an average of just 79.38 steps across diverse test cases, including those in noisy environments.
- Enhanced the **Stanley controller**, surpassing previous results with a 100% success rate and an average of 79.4 steps in more challenging and noisy test scenarios.
- Utilized **State Feedback Linearization** on a differential drive system controller with 100% success and 76 steps average

ORB SLAM 3 (Hardware Project) | Northeastern University **Nov 2023 – Dec 2023**

Implemented ORB SLAM 3 using ROS and a fisheye camera to generate outdoor maps and test the algorithm's limits

- **Collected data** for various scenarios to test the limits of the algorithm, gathering a dataset of over 5 scenarios to analyze robustness in real-world applications
- **Calibrated the camera parameters** using Calibr and achieved an average reprojection error below 1 pixel, enhancing the precision of visual odometry calculations
- Implemented advanced **sensor fusion** techniques to integrate IMU data from NUANCE autonomous car, resulting in a 30% improvement in the algorithm's accuracy
- Conducted rigorous testing and evaluation of various AI solutions including **YOLO v5, Dyna-Slam, and Monocular depth estimation**, leading to a 25% decrease in false positives and an overall enhancement of the algorithm's performance

Dead Reckoning (Hardware Project) | Northeastern University **Oct 2023 – Nov 2023**

Implemented dead reckoning algorithm using Vectornav VN-100 IMU to track odometry in instances where GPS signal was lost, resulting in accurate path estimation during tunnel navigation. Wrote Python drivers for GPS and IMU for data collection.

- Calibrated the **magnetometer** for hard and soft Iron defects, improving the accuracy of heading estimation by 20% and reducing errors in path calculation.
- Utilized **advanced filtering techniques** such as **moving mean and jerk estimation** to eliminate sensor biases and improve the quality of readings.
- Successfully estimated dead reckoning path using integrated accelerations to calculate velocity and displacements, achieving a 90% correlation between dead reckoning path and **GPS**-recorded path on smooth roads with sharp turns.

Autonomous Mars Rover (Simulation/Hardware Project) | NMIMS University **Jul 2022 – Aug 2023**

Engineered a versatile mobile manipulator hardware prototype with a 4WD base, 5 DOF arm and several sensors in ROS and Gazebo. Capable of autonomous navigation and 3D mapping.

- Designed parts in **SolidWorks and Fusion 360**, machined the chassis from aluminium and 3D printed the gripper to complete the mechanical design.
- Implemented **RTAB SLAM** with **KinectV2** and a **2D Lidar** in **ROS**, testing **planning algorithms** (DWA, Teb, Cartographer) with **Advanced Monte Carlo Localization** to complete the navigation system development.
- Developed a **GPS**-based navigation goal system for outdoor navigation, using **Dead Reckoning** in the absence of a signal.
- Created an **Inverse Kinematics** script in C++ for remote control of the manipulator's arm using a laptop.

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Patrol Bot: Autonomous Security Robots (Hardware Project) | NMIMS University **Jul 2021 – Aug 2023**

Engineered an inconspicuous surveillance bot designed as a low-cost add-on to CCTV systems, automating nightshift monitoring to address potential lapses in human guard attention. The system as a whole implemented swarm robotics with multiple units.

- Implemented a noise-efficient **PID-Bug 1 algorithm** for navigation on a custom Arduino mega with an ESP32 module.
- Developed Artificial intelligence-based Night Vision-based **object detection using Inception V2** Convolution Neural Network for enhanced surveillance capabilities.
- Established IoT system using **Thingspeak and IFTTT**, enabling real-time alerts through calls, emails, Twitter & MQTT.

PLC Controllers for Various Applications (Simulation Project) | NMIMS University **Oct 2022 – Nov 2022**

Designed PLC ladder logic programs for various industrial applications, incorporating concepts such as timers, counters, latching, and interlocking. Incorporated a safety switch linked to an emergency stop button in all programs.

- Designed a bottle-filling mechanism that utilized a level sensor to stop the filling process, activate the conveyor for the next bottle, and lock the conveyor using **interlocking** while the filling process was in progress.
- Developed a **stepper motor controller** that generated square wave frequencies using timers to drive a **DM452** stepper driver including the functionality to switch the motor direction and a safety mechanism to stop the motor.
- Designed a packaging system that used **counters and timers** to count the number of items in a box and initiate packaging.

Wheelie the 2WD (Simulation Project) | Personal Project **Jan 2022 – Feb 2022**

Developed an Autonomous two-wheeled robot optimized for precise indoor navigation using 2D lidar SLAM on ROS & Gazebo.

- Designed the Mechanical system in **SolidWorks**, containing a rounded rectangular body, 2-wheel mounts, a castor wheel mount and lidar mount, which was also used to generate a **URDF**.
- Simulated the robot in **Gazebo** using the inbuilt **gazebo plugins** for differential drive and lidar to test out different **algorithms** (Pure Pursuit, MPPI, RRT, DWA, Teb, Cartographer), decided on DWA due to ease of tuning.
- Utilized the advanced **DWA planner** for indoor mapped situation and tested on a 3D hardware prototype to validate the simulation results and tuned parameters like biases, inflation, costs to improve the **behavior**.

LabView Laser Turret (Hardware Project) | Personal Project **Jan 2022 – Feb 2022**

Engineered an advanced laser turret system incorporating a high-resolution camera, dual servo motors, a precision laser module, and an Arduino controller, targeting enhancements in military technology applications.

- Developed an intuitive keyboard interface for dynamic turret control, utilizing **event-driven programming** to adjust servo positions in real-time based on user input.
- Innovated a mouse-driven control mechanism by establishing a **responsive mapping** between the cursor's screen position and the servo motors' range of motion, facilitating precise laser targeting through a virtual mousepad interface.
- Seamlessly integrated a **live-feed camera** module equipped with a custom crosshair overlay, leveraging the **IMAQ** toolbox to enhance operational accuracy with **real-time** visual feedback.

Publications

- A. Amir, A. Chandgothia, M. Goel, D. Sawant and N. Thakur, "Design and Implementation of an IoT Based Patrol Robot," 2022 IEEE Bombay Section Signature Conference (IBSSC), Mumbai, India, 2022, pp. 1-6, doi: 10.1109/IBSSC56953.2022.10037325
- A. Amir, A. Verma, A. Goswami, A. Kabra, S. Nakhye and S. Chaudhary, "Design and Analysis of Strawberry-Picking Industrial Robotic Arm," 2022 IEEE Bombay Section Signature Conference (IBSSC), Mumbai, India, 2022, pp. 1-6, doi: 10.1109/IBSSC56953.2022.10037337

Extra-Curricular

- Founded and currently supervising College Mars Rover Team in technical and management aspects
- Won two ISA scholarships, awarded to individuals with demonstrated potential in the field of Robotics and Automation
- Volunteered at RCBA for beach cleanups, blood donation drives, underprivileged mentorship programs & charity events
- Served as a member of the programming department in Robocon
- Currently participating in NU robotics club robot dog project