Adnan Amir

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Education

Northeastern University, Boston, MA   **May 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
July 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

Nordson Corporation   **May 2024 – August 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**

Northeastern University   **January 2024 – May 2024**
Graduate Teaching Assistant, EECE 4649
- Assisted in developing and delivering course materials for EECE 4649, focusing on numerical techniques and their applications in solving scientific and engineering problems using MATLAB and Python.
- Provided personalized guidance during office hours and review sessions, helping students understand and implement numerical solutions for linear and nonlinear systems, numerical integration and differentiation, ordinary differential equations, interpolation, least squares theory, and numerical optimization techniques.

Automata Systems   **May 2023 – July 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

LearnByResearch   **December 2021 – December 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 – July 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 – April 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

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Projects

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   **March 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   **February 2024 – March 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   **February 2024 – March 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   **February 2024 – March 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   **January 2024 – February 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**

Content-Based Image Retrieval (Hardware Project) | Northeastern University   **January 2024 – February 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.

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- 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   **December 2023 – January 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   **October 2023 – January 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   **November 2023 – December 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   **October 2023 – November 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   **July 2022 – August 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.

Patrol Bot: Autonomous Security Robots (Hardware Project) | NMIMS University   **July 2021 – August 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   **October 2022 – November 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.

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- 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   **January 2022 – February 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   **January 2022 – February 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