

Nathan Cusson-Nadeau

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PROFESSIONAL SUMMARY

Mechanical Engineer and recent Master's in Mechanical Engineering graduate specializing in robotics & controls with over 3 years of experience in hands-on robotics and controls research, autopilot software development, and building control system design. Expertise in advanced control theory, state estimation, robotics (sensing, learning, and motion planning), and probability theory.

SKILLS

- **Programming:** Python (JAX, OpenCV, CasADi), C/C++, MATLAB (Control Systems Toolbox), Rust, HTML
- **Control Techniques & Theory:** Classical (PID), Modern (LQR, LQG, MPC, CLFs, CBFs, Reachability)
- **State Estimation:** Bayesian Filtering (Extended & Unscented Kalman Filter, Particle Filter), Motion Capture, Simultaneous Localization and Mapping (SLAM, VI-SLAM, FastSLAM)
- **Motion Planning:** Dijkstra's, A* (LRTA*, RTAA*, ARA*), Jump Point Search (JPS), Rapidly exploring Random Tree (RRT*), Probabilistic Road Map (PRM)
- **Robotic Frameworks & Packages:** Robot Operating System (ROS), Gazebo, ROS1-to-2 Bridge, RVIZ
- **Hardware:** AutoCAD, SolidWorks, Fusion360, 3D Printing
- **Machine Learning:** Supervised Learning (Logistic Regression), Reinforcement Learning (Policy Iteration, Value Iteration)

EDUCATION

Master of Science (MS) in Mechanical Engineering - Robotics & Controls September 2021 - July 2023
University of California, San Diego La Jolla, CA

Bachelor of Science (BS) in Environmental Engineering September 2013 - June 2017
University of California, San Diego La Jolla, CA

RELEVANT WORK EXPERIENCE

Graduate Robotics Researcher September 2021 - Present
Contextual Robotics Institute | Safe Autonomous Systems Lab La Jolla, CA

- Validated cutting-edge safety enforcement algorithm can be successfully deployed in a **hardware-in-the-loop (HIL)** use case in the presence of changing obstacles on a **mobile robot** with motion capture for **near-perfect state estimation**.
- Implemented an **advanced optimal safety-agnostic goal-seeking control law** for **highly nonlinear** system dynamics.
- Developed complete software package in **Linux** for safe autonomous robots using the **Robot Operating System (ROS)**, **Python**, **C++**, **XML**, and **YAML** with custom **Gazebo physics simulation** for **software-in-the-loop (SIL)** testing.
- Mentored **4** university students and wrote user guides and theoretical background documentation resulting in **improved productivity** for the lab.

RELEVANT WORK EXPERIENCE CONT.

Autopilot Software Engineer - Intern

June 2022 - September 2022

General Atomics Aeronautical Systems

Poway, CA

- Developed new **regression tests** for **world-leading UAS's** NGPS **autopilot** landing system using **Python, C,** and **SVN** for version control. This required an intimate understanding of how **Kalman Filtering** of proprietary sensor data was used for **precise state estimation** to enable **safe automated landing** in GPS-denied scenarios.
- Performed successful software-in-the-loop **unit testing** of the code using ground control station and drone flight simulator, validating **12+ software requirements specifications** for the NGPS system.
- Presented final work to the **Vice President of Software Engineering** in a 15-minute presentation.

Controls Engineer II

October 2019 - December 2020

Emcor Services - Mesa Energy Systems

Irvine, CA

- Designed **advanced building automation control systems** for notable clients such as NASA JPL, UCLA, Cal Tech, NBC Universal using **PID control, AutoCAD,** and **Microsoft Excel,** improving electrical efficiency by **over 5%.**
- **Automated** the laborious process of constructing BOMs using **VBA** and **AutoCAD** saving **\$10,000** or more.
- Developed standardized drawings to represent standard **microcontrollers, sensors, actuators,** and wiring, **resulting in increased readability and consistency** of engineering drawing submittals.

Controls Engineer I

April 2018 - October 2019

Albireo Energy

Poway, CA

- Designed **Building Automation Control Systems (BACS)** for over \$4 million worth of contracts for the Greater San Diego region.
- **Engineered the control system** for the new: UCSD graduate housing campus; Apple campus; and Prof. Barreiro's Ultracold Strontium Laboratory.

Environmental Engineer

September 2017 - April 2018

SCS Engineers

Carlsbad, CA

- Completed **air emission calculations** and **air dispersion modeling** to ensure clients' compliance with air pollution regulations in their respective county, city and state utilizing **ArcGIS.**
- **Detected** early signs of a **production stream leak** during a volatile organics inspection at Illumina's San Diego facility.
- **Analyzed tracer gas, odor observations and wind velocity vector data** from a City of San Diego landfill tracer study to produce **graphs illustrating correlations** between odor sources and observations.

NOTABLE PROJECTS

Testing and Validation of Novel Safe Control Technique

September 2022 - July 2023

- Validated the applicability of the **bleeding-edge** algorithm [refineCBF](#) in **safety-critical control hardware-in-the-loop** settings using a **fully-autonomous differential-drive robot.**
- Individually developed a complete **ROS [software package](#)** using **Python, C++, YAML,** and **XML** for the [Safe Autonomous Systems Lab](#) in the Contextual Robotics Institute.
- Achieved **near-perfect state estimation (< 1mm)** of the robot's true pose using a **Vicon camera MoCap system.**

NOTABLE PROJECTS CONT.

Robot Learning Platform

January 2021 - Present

- Developing a **robot test platform** for independent **hands-on** learning of real **mobile robot system**.
- Utilized **Fusion 360** to **3D model** robot chassis for **3D printing**.
- Programmed **Arduino Uno and Micros** to perform **signal processing** of encoder feedback for odometry information to use in control algorithms using **C++**.

LQG Controller for Boeing 747

June 2022

- Designed a **yaw damper system** for a **Boeing 747** during cruise flight using the **MATLAB** control systems toolbox.
- Crafted a **Linear Quadratic Gaussian (LQG)** controller to **achieve** a damping coefficient of > 0.35 and natural frequency of < 1 rad/sec which supplanted a washout filter that allows for a **roll** angle to be held while altering the plane's **yaw**.

Infinite-Horizon Stochastic Optimal Control

June 2022

- Implemented a **receding-horizon optimal control algorithm**, where a **differential-drive robot** is to **follow a reference trajectory while remaining safe** from obstacles in the presence of stochastic disturbance.
- Resulting algorithm **yielded 0 collisions** with a maximum reference tracking **error of about 10%**.

Search-Based Motion Planning

May 2022

- Implemented a novel **modified weighted A* search algorithm** to use as the motion planner for a pursuer in a pursuit-evasion game.
- Provided **dramatically improved computational tractability by over 100x** with minor suboptimality in larger and more challenging configuration spaces.

Dynamic Programming

April 2022

- Used the **dynamic programming principle** to find the **optimal control policy** for an agent to traverse to a goal behind a locked door in a random grid-world environment with an **8 dimensional** state-space.
- Received **highest grade in the class** for implementation and report.

Particle Filter SLAM

February 2022

- Implemented a **particle filter** for **Simultaneous Localization and Mapping (SLAM)** of an **autonomous car** using real **2D LiDAR** sensor data in a city.

Color Classification and Recycling Bin Detection

January 2022

- Trained a pixel classifier using **logistic regression** to identify colored trashcans in an assortment of images using the **OpenCV Python** library.
- Achieved **81% pixel classifier** and **100% recycling bin detection accuracy** on test sets.

River Trash Filtration Array

September 2016 - June 2017

- Served as **engineering project lead** for a river trash filtering system which aimed to **mitigate pollution** in the ocean.
- Designed and manufactured **proof of concept (PoC)** 3D printed array of pillars using **computer aided design (CAD) 3D Modeling** and **Computation Fluid Dynamics (CFD)** in **Solidworks**.

NOTABLE PROJECTS CONT.

[UCSD Solar Car](#)

September 2016 - June 2017

- Designed and manufactured a **solar powered car** for the **American Solar Challenge** as part of the mechanical team.
- Conducted **finite element analysis (FEA)** to various mechanical components expected to experience the highest stress during operation to ensure they fulfilled the competition's specifications for **factors of safety**.

CERTIFICATIONS

NCEES - Engineer in Training (EIT)

Coursera - C Programming Language Fundamentals

RELEVANT COURSES

Control Theory: Linear & Nonlinear Systems, Linear & Nonlinear Control Design, and Optimal Control

Robotics: Sensing & Estimation, Motion Planning & Learning

Probability & Statistics: Advanced Probability & Statistics for Data Science

MISCELLANEOUS

Languages: English (Native), French (Proficient), Spanish (Proficient)

Hobby Projects: Text-Based Dungeon Crawl Game in C++, Robotic Learning Platform

Extracurriculars: RoboGrads, Triton Robotics - AI Team