Behzad Farzanegan

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PROFESSIONAL SUMMARY

Skilled Control Engineer with a Ph.D. in Electrical Engineering, specializing in control and navigation systems for autonomous vehicles, including aerial, ground, and underwater vehicles and robotic manipulators. Expertise in designing and implementing advanced navigation and control algorithms, such as deep reinforcement learning-based control, optimal control, and model predictive control (MPC) for linear and nonlinear systems. Proficient in sensor fusion, Kalman filtering, system identification, path planning (e.g., A*, RRT), and simultaneous localization and mapping (SLAM) in challenging environments. Extensive experience in real-time system development using MATLAB/Simulink, Python, and C++, with a background in HIL testing, system validation, and field testing.
U.S. person with permanent residency obtained through EB-2 NIW, fully authorized to work in the U.S.

Skills

- **Programming Languages**: Python, MATLAB/Simulink, C/C++
- **Control and Estimation**: Classical and modern control systems theory, Learning based control, Kalman filter, PID, MPC, Sensor fusion, Localization, Optimal control, Adaptive control, Sliding mode control, Monte Carlo simulation
- **Robotics Frameworks**: ROS2, ROS2_control, SLAM, Gazebo, Nav2, MoveIt, Path Planning (A*, RRT), CANape
- **Machine Learning**: Deep Learning, Neural Networks, Reinforcement Learning, Computer Vision, Keras, OpenCV
- **Development Tools**: Version Control (Git), RTOS, Hardware-In-The-Loop (HIL), Linux, Microcontroller

Work Experience

Embedded Control Software Engineer
Caterpillar Inc| Peoria, IL| April 2025 - Current

- Developed a MATLAB/Simulink Energy Management System (EMS) supervisory control for mining site operations, integrating utility, PV, battery, and gensets, achieving 20% reduction in BSFC through PSO-based optimal load.
- Implemented time-series load forecasting using LSTM neural networks and Holt-Winters models, improving EMS scheduling accuracy and reducing operational costs.
- Modularized Simulink components of the EMS model for production-ready deployment and generated Embedded C code for ECU (A6L3), validated via CANape testing.
- Designed and deployed fault detection and predictive maintenance systems for pumps and gensets, using vibration, oil contamination, speed, voltage, current, and image data, applying classical ML, CNN, and LSTM models with feature engineering and cross-validation, achieving ~89% classification accuracy.
- Developed image-based valve defect detection using CNNs and HOG feature extraction, enabling automated quality inspection and fault prediction.

Graduate Research Assistant
Missouri University of Science and Technology | Rolla, MO | Sep 2021 – April 2025

- Designed and implemented reinforcement learning-based optimal control systems for UAVs and autonomous cars, utilizing HIL simulation with IMU and optical sensors for state estimation, localization, and path planning.
- Developed safe reinforcement learning-based control for Autonomous Underwater Vehicles (AUVs) using Deep Neural Networks (DNN) in MATLAB/Simulink, achieving a 31% reduction in operational costs.
- Created explainable and Safety-Aware Deep Reinforcement Learning-based (DRL) control systems and state estimation for Autonomous Surface Vessels (ASVs), integrating path planning with A* and object avoidance.
- Accomplished multitasking optimal learning-based controller for robotic manipulators using a lifelong learning technique

Visiting Scholar
University of Newcastle | Newcastle, Australia | Jan 2018 – Jul 2018

- Developed NN-based optimal control and state estimation for Surface Effect Ships (SES) with control input saturations in MATLAB/Simulink, achieving 97% vertical motion damping.
- Designed a data-driven distributed optimal control and state estimation framework for nonlinear interconnected systems using Neural Networks (NN) and Monte Carlo methods, reducing computational burden and cost.

Education

Ph.D. in Electrical Engineering- Emphasis: Control Systems and Robotics

Missouri University of Science and Technology |GPA:3.77| Aug 2021 – May 2025

- Dissertation: "Lifelong Learning Safety-Aware Deep Reinforcement Learning Control for Autonomous Vehicles"
- Received funding from the Office of Naval Research (ONR) and Army Research Office (ARO).

Projects

State Estimation and Control for QCar

- Implemented Kalman filters for sensor fusion and state estimation using IMU and gyro data on the Quanser QCar test bench.
- Designed and deployed PID, and backstepping controllers to enhance QCar's motion stability and control accuracy.

Bumper Robot Development

- Designed and built a bumper robot from scratch using ROS2, Python, and C++, incorporating a custom joystick interface and a simple controller leveraging ROS2 control with Bayesian state estimation for odometry.

Autonomous Car Simulation

- Applied Model Predictive Control (MPC) and PID to an autonomous car, simulating and animating the system in Python.
- Conducted localization through sensor fusion using GNSS, IMU, and LiDAR.

Self-Driving Car with CNN

- Programmed a fully functional self-driving car using Convolutional Neural Networks (CNN) and computer vision to identify and follow lane lines on a road in Python with Keras and ROS2.

UAV Design and Simulation

- Designed and simulated a 12-degree-of-freedom UAV using MPC and Kalman filter for state estimation.

Embedded System Development

- Programmed ATmega16 microcontrollers to measure the temperature of a wax actuator using a TMP36 sensor, implementing a real-time embedded PWM controller for a micro peristaltic pump.

Selected Publications

Behzad Farzanegan, Jagannathan Sarangapani. "Robust Resilient Safe Deep RL-based Control of Rear-Wheel-Drive Autonomous Vehicles under adversarial attacks." IEEE Transactions on Neural Networks and Learning Systems (under review)

Behzad Farzanegan, Jagannathan Sarangapani. "Explainable and Safety Aware Deep Reinforcement Learning-based Control of Nonlinear Discrete-Time Systems Using Neural Network Gradient Decomposition" IEEE Transactions on Automation Science and Engineering (2025)

Behzad Farzanegan, Jagannathan Sarangapani. " Multi-Model Safe Neuro-Optimal Output Tracking Control of Autonomous Surface Vessels with Explainable AI." 2025 IEEE Conference on Control Technology and Applications (CCTA)

Behzad Farzanegan, Jagannathan Sarangapani. " Reinforcement Learning-Based Constrained Optimal Control of Strict-feedback Nonlinear Systems: Application to Autonomous Underwater Vehicles." 2024 IEEE Conference on Control Technology and Applications (CCTA) (2024)

Behzad Farzanegan, Rohollah Moghadam, Jagannathan Sarangapani, P. Natarajan. "Optimal Adaptive Tracking Control of Partially Uncertain Nonlinear Discrete-time Systems using Lifelong Hybrid Learning: Application to Robotic Manipulators" IEEE Transactions on Neural Networks and Learning Systems (2023)

See more publications in my Google Scholar: https://scholar.google.com/citations?user=kyEt7S8AAAAJ&hl=en&inst=15611845720231691803

Licenses & Certifications

- Fundamentals of Deep Learning (NVIDIA)
- ROS2 Self-Driving robot with Python and C++. Odometry, Control, and Sensor Fusion using Kalman Filters (Udemy)
- Robotics and ROS 2 - Learn by Doing! Manipulators (Udemy)
- Self Driving and ROS 2 - Learn by Doing! Map & Localization (Udemy)
- Machine Learning A-Z: AI, Python Machine Learning A-Z (Udemy)
    - Skills: Data Preparation, Regression Analysis, Classification, clustering, Reinforcement Learning, Natural Language Processing (NLP), Deep Learning, Convolutional Neural Networks (CNN), Model Selection)
- Applied Control Systems 3: UAV (3D Dynamics & control) (Udemy)
    - *Skills: Modeling + state space systems + Model Predictive Control + feedback control + Python simulation*
- The Complete Self-Driving Car Course - Applied Deep Learning (Udemy)
    - *Skills: Computer vision, Deep learning*
- Python for Computer Vision with OpenCV and Deep Learning (Udemy)