

COVER LETTER

Faculty Search Committee
Department of Mechanical Engineering
Example University

Dear Search Committee Members,

I am writing to apply for the Tenure - Track Assistant Professor - Mechatronics position in the Department of Mechanical Engineering at **Example University**. I am a Ph.D. candidate in Mechanical Engineering in a cooperative doctoral program jointly administered by Southern Illinois University Edwardsville (SIUE) and Southern Illinois University Carbondale (SIUC). My research focuses on control and estimation theory, time-delay systems, and autonomous robotics, with an emphasis on developing computationally efficient estimators and decision-making frameworks that compensate for sensing and actuation delays.

My recent work advances pose estimation for SLAM systems and perception-driven planning for autonomous robots. I design psychologically inspired, sensor-integrated motion-planning frameworks that combine theoretical control with real-time data from LiDAR, RGB-D cameras, and IMUs. These efforts shape my long-term vision: establishing an interdisciplinary research group where modern estimation, autonomous systems, and emerging AI tools jointly advance robust and adaptive robotic intelligence.

I have taught multiple undergraduate and graduate courses as an independent instructor at SIUE and at K. N. Toosi University of Technology. My teaching emphasizes project-based learning, mathematical modeling, and hands-on experimentation, providing students with both theoretical understanding and practical skills.

I am excited about the opportunity to contribute to **Cal Poly SLO** through impactful research, committed teaching, and active collaboration. I have enclosed my CV, research statement, teaching statement, and references. Thank you for your consideration.

Sincerely,

Hamed Mozaffari

CURRICULUM VITAE

CONTACT INFORMATION

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EDUCATION

- **Ph.D., Engineering Science (in Robotic track)**
Southern Illinois University Carbondale (SIUC), AUG 2022 – JUN 2026 (expected)
Dissertation: *High-Precision Rigid Body Pose Estimation Using Constrained Sensor Fusion with Delay Compensation* GPA-4/4
- **Ph.D., Mechanical Engineering (Control and Dynamics)**
K. N. Toosi University of Technology, AUG 2011 – OCT 2019
Dissertation: *Modeling Human Driver Behavior Based on Task-Difficulty Homeostasis Theory to Improve Drowsy Driver Assistance Systems in a Driving Simulator* GPA-3.75/4.
- **M.Sc., Mechanical Engineering (Control and Dynamics)**
K. N. Toosi University of Technology, AUG 2007 – OCT 2010
Thesis: *Modeling human driver behaviors in a driving simulator* GPA-3.78/4.
- **Ph.D., Mechanical Engineering**
K. N. Toosi University of Technology, AUG 2011 – OCT 2019 (expected)
Dissertation: *Gear Shift Strategy for Optimized Fuel Consumption and Longitudinal Performance* GPA-3.16/4.

PUBLICATIONS

- H. Mozaffari and A. Dabiri (2025), “Precision Quaternion Estimation with Partially Norm-Constrained Unscented Kalman Filtering,” *ASME Letters in Dynamic Systems and Con-*

trol.

- H. Mozaffari and A. Dabiri (2023), “A Comprehensive Dynamic Continuous Impact Model with Plastic Deformation,” *IDETC/CIE*.
- H. Mozaffari and A. Nahvi (2020), “A Motivational Driver Model for Rear-End Crash Avoidance,” *Journal of Systems and Control Engineering*.
- H. Mozaffari and A. Nahvi (2019), “Modeling Driver Behavior in Complicated Traffic Using Psychological and Control Methods,” *Modares Mechanical Engineering*.
- H. Mozaffari and A. Nahvi (2018), “A Motivational Driver Steering Model: Task Difficulty Homeostasis,” *Cognitive Systems Research*.
- F. Gharagozlou, A. Mazloumi, G. N. Saraji, A. Nahvi, M. Ashouri, and H. Mozaffari (2015), “Correlation Between Driver Subjective Fatigue and Bus Lateral Position,” *Electronic Physician*.
- A. Mazloumi, F. Gharagozlou, J. Nasl Saraji, A. Nahvi, M. Ashouri, and H. Mozaffari (2014), “Estimating Bus Driver Fatigue Through Performance Measures in a Virtual Environment,” *Shefaye Khatam Neuroscience Journal*.

INDUSTRY EXPERIENCE

Nasir Tech Co., Tehran, Iran

Automotive and Control Engineer, Supervisor: Dr. Ali Nahvi Sep. 2014 – Dec. 2018

- Developed computationally efficient 6-DOF and 14-DOF ground-vehicle dynamic models in C++ for traffic simulation platforms.
- Implemented high-fidelity 14-DOF models of 2- and 4-wheeled vehicles using the NVIDIA PhysX SDK for driving simulators.
- Validated vehicle models against CarSim simulations and experimental data from Iranian vehicle tests.
- Managed real-time haptic steering feedback in a driving simulator via torque control of AC servo motors in C++ and LabVIEW.
- Designed a zero-backlash gearbox to enable accurate, responsive haptic interaction between simulator and driver.
- Controlled AC servo motors to actuate a parallel robotic platform for a motion-based driving simulator.

Niroo Research Institute, Tehran, Iran

Mechanical Engineer, Supervisor: Dr. Morteza Fathi

Aug. 2010 – Dec. 2012

- Designed a 2 MW wind-turbine gearbox shell in SolidWorks and performed structural stress analysis in ANSYS.
- Modeled and simulated a planetary gearbox for a 2 MW turbine using Simscape in MATLAB.
- Conducted fatigue analysis of the gearbox shell in ANSYS to evaluate durability under operational loads.
- Designed sealing and bearing systems to ensure reliability and reduce maintenance.

RESEARCH EXPERIENCE

Development of Estimation Package ADROCO Research Group, SIUE, Edwardsville, IL, Sep. 2023 – Dec. 2024

Graduate Assistant, Supervisor: Dr. Arman Dabiri

- Developed a sensor-fusion estimation package for pose estimation under delayed measurements and norm constraints, integrating IMU, LiDAR, and camera data for robotic systems, including AV and ADAS applications.
- Implemented modified EKF, UKF, and CKF algorithms tailored for delayed-measurement scenarios [?].
- Worked on employing LSTM-based learning to estimate noise covariance for systems with unknown or time-varying stochastic uncertainties using PyTorch and TensorFlow.

Development of Path Planning Package ADROCO Research Group, Edwardsville, IL, Aug. 2022 – Aug. 2023

Graduate Assistant, Supervisor: Dr. Arman Dabiri

- Developed a robust path-planning framework combining graph-based, sampling-based, and optimization-based approaches, including MPC, to improve planning reliability and performance.
- Designed a reinforcement-learning strategy to guide sampling-based planning, enabling smooth motion generation for a 6-DOF Trossen robotic arm.
- Built an inverse-kinematics model using CNNs in PyTorch and TensorFlow, trained on Gazebo simulation data and validated on a 6-DOF Trossen arm; achieved sub-millimeter position accuracy and quaternion orientation error below 0.01.

- Developed a human driver model for near-crash behavior prediction using a Lyapunov function grounded in psychological motivations for steering control; calibrated via parameter identification in SIL tests, achieving a mean prediction error of 7% [?].
- Designed a multi-objective motivational decision model for near-crash scenarios; the resulting AV algorithm outperformed 10 human drivers in SIL driving-simulator tests, with an activation function yielding zero false positives/negatives; implemented in C++ for SIL and MATLAB/Simulink for demos [?].
- Applied the model to a drowsy-driver assistance system coordinating autonomy with motivation-based activation logic; SIL tests with 15 professional bus drivers showed perfect activation with no false positives/negatives [?, ?].
- Extended the motivational framework with Q-learning and a motivation-driven reward to handle dynamic, non-collision traffic decisions; verified in MATLAB/Simscape/SimDriveline using a 6-DOF planar vehicle model, achieving a 91.8% optimal-decision success rate.

TEACHING EXPERIENCE

As an **independent instructor** at Southern Illinois University Edwardsville (SIUE) and K. N. Toosi University of Technology, and Azad University in Hashtegerd Branch I have redesigned and taught multiple undergraduate courses. My role goes beyond classroom teaching—I independently develop syllabus, lectures, assignments, and laboratory projects, manage grading, and mentor students in both theoretical and experimental components.

- **Sensors and Actuators:** Designed and implemented lab-based instruction using LiDAR, IMU, and encoder systems to connect sensor modeling with control applications.
- **Integrated Mechatronics with Raspberry Pi:** Sole instructor for MATLAB-based numerical analysis; developed lectures, projects, and exams covering curve fitting, numerical integration, and ODE solving.
- **Dynamic System Lab:** Independently created hands-on lab modules integrating Arduino, LabVIEW, and real-time data acquisition; supervised student design projects linking hardware and control algorithms.
- **Ground Vehicle Dynamics** Teaching the course and designing modeling and simulation projects for ground vehicle dynamics aligned with automotive industry demands.

- **Automatic Control** Teaching the fundamental concepts and designing hands on projects including control loop design in different industries like process control, automation, robotics, and automotive applications.

Also as an **adjunct instructor** at Azade University in Hashtgerd campus, I have taught multiple undergraduate courses.

- **Industrial Design and Drawing:** Teaching the fundamentals of conceptual desing and Technical Drafting and Drawing. Design of projects using Autocad and solidworks for technical drafting of mechanical machines.
- **Machine Design by Computers** Teaching how to apply principles of mechanical component design and Mechanism analysis in technical design of machines and mechanisms. Designing projects that students start from analytical design to drafting the design by technical drawing and documenting technical data sheets.
- **Finite Element Analysis by ANSYS** A project based course starts by teaching the fudumentals of Finite-Element-Analysis and how to use ANSYS for structural, static, dynamic, and combined solid-fluid systems.
- **Engineering Programming:** Teaching the basics of logic, algorithms, and designing hands on projects in C++ and Matlab. Teach students to find the best programming tool for different phases of design and implementation like prototyping, real time control, or software development.

I was previously recognized with the *Outstanding Instructor Award* (2014 and 2016) Based on student evaluation results in Azad University of Hashtgerd branch.

HONORS & AWARDS

- Outstanding Instructor Award, H.I.A.U. (2014 and 2016)
- Research Grants for Graduate Students (RGGS)

TECHNICAL SKILLS

- **Mechanical Design:** Ansys, SolidWorks.
- **Mechatronics Skills:** Embedded controller (Raspberry PI), Communication Protocols (I2C, SPI, UART, CAN).
- **Sensors:** LiDAR, Camera, Radar, IMU, Thermal, Optic, Altrasound, Vision, and Mechanical sensors.

- **Programming:** C/C++, Python, Matlab
- **Tools & Platforms:** Simulink, ROS, CAN, Raspberry Pi, NVIDIA Jetson, LabVIEW

RESEARCH STATEMENT

RESEARCH OVERVIEW

My research lies at the intersection of delayed nonlinear estimation, human-centered autonomy, and robotic perception and control. I develop mathematically rigorous yet computationally efficient algorithms that allow autonomous systems to operate reliably under uncertainty, nonlinear dynamics, and time-varying delays. Motivated by robotics and transportation applications, my work bridges theoretical analysis with physical implementation on real robotic systems.

I have contributed to delayed-state Bayesian estimation through a reorganized *augmented lead-measurement* formulation that preserves state dimension and enables recursive EKF, UKF, and CKF filtering under asynchronous and delayed sensor data [1]. I also developed a partially norm-constrained UKF for quaternion-based orientation tracking, improving stability in rigid-body estimation problems [2]. Earlier in my career, I worked on human driver modeling, producing psychologically grounded computational models for rear-end crash avoidance, steering control based on task-difficulty homeostasis, and fatigue-related performance degradation [3, 4, 5]. These data-driven models strengthened my long-term interest in human-centered autonomy. My robotics experience includes implementing LiDAR-IMU-RGB-D fusion pipelines, embedded C/C++ and Python development, ROS2-based control, and integration of manipulators and mobile robots. These platforms allow me to validate theoretical algorithms through experimental robotics.

PAST AND CURRENT RESEARCH

Human Driver Modeling and Psychology-Guided Motion Planning. My early research focused on understanding human driving behavior using tools from nonlinear control, psychology, and vehicle dynamics. I developed models for rear-end crash avoidance, steering control based on task-difficulty homeostasis, and driver-state variations related to comfort, risk, and fatigue [3, 4, 5]. These models reproduced human behavior with high fidelity and motivated my long-term interest in human-centered autonomy and motion planning for ADAS and autonomous vehicles.

Delay-Aware Estimation, SLAM, and Analytical-Constrained Perception for Robotics.

A central challenge in SLAM is achieving feasible and reliable state estimation under robotic analytical constraints, time-varying delays caused by multi-rate sampling, variable sampling intervals, and missed measurements. My work addresses these obstacles through a unified constrained and delay-aware estimation framework. I introduced the *augmented*

lead-measurement model, which handles asynchronous and delayed data without state augmentation and improves numerical stability in LiDAR–IMU–RGB-D fusion [1, 6]. In parallel, I developed a partially norm-constrained UKF that enforces quaternion unit-sphere feasibility and enhances robustness during rapid motion [2]. Together, these methods provide a foundation for reliable SLAM and perception pipelines operating under realistic sensing conditions. I am currently implementing and evaluating these algorithms on multi-sensor robotic platforms using LiDAR, IMU, RGB-D, and ROS2-based embedded systems.

PROPOSED RESEARCH PROJECTS AND FUNDING OPPORTUNITIES

Project 1: Learning- and Constraint-Augmented Delay-Aware Sensor Fusion.

This project will develop a unified perception framework that embeds analytical robotic constraints and neural delay models inside Bayesian filters to address multi-rate sensing, variable latency, and dropped measurements. The approach integrates unit-norm, geometric, and kinematic constraints into EKF/UKF/CKF updates while learning nonparametric delay distributions using temporal neural networks. Delay and constraint uncertainty will be jointly propagated to maintain estimator feasibility and robustness. Experimentally, the framework will be tested on LiDAR–IMU–RGB-D robotic platforms using ROS2-based asynchronous pipelines, programmable delay modules, and real-world degradation scenarios. Evaluation metrics include covariance consistency, constraint satisfaction, and trajectory accuracy under timing irregularities. *Potential Funding:* NSF CISE/CPS/NRI, ARO Computing Sciences, ONR Science of Autonomy, Toyota Research Institute.

Project 2: Human-Centered Autonomy Using Psychologically Informed Models.

This project incorporates human psychology—risk perception, comfort, fatigue, and task difficulty—directly into motion planning and shared-autonomy control. Behavioral prediction models will be embedded into optimization-based planners through psychology-aware cost functions, intent priors, and adaptive safety envelopes. Methodology includes modeling human trajectories, estimating internal driver states, and generating intuitive trajectories that align with human expectations. Experiments will combine a VR/steering-wheel driving simulator for human-in-the-loop data collection with a scaled autonomous vehicle testbed for real-time evaluation of trust, comfort, and control smoothness. *Funding:* NSF CHS, Smart & Connected Communities, USDOT UTC, NHTSA Vehicle Safety Research Grants, OEM ADAS programs.

REFERENCES

- [1] H. Mozaffari and A. Dabiri, “Iterative augmented lead measurement method for efficient nonlinear motion estimation with delayed measurements,” in *Proceedings of IMECE*

2025, 2025, paper IMECE2025-166124.

- [2] H. Mozaffari, “Partially norm-constrained unscented kalman filtering for quaternion-based motion estimation,” Technical Report, Tech. Rep., 2023.
- [3] H. Mozaffari and A. Nahvi, “Rear-end crash avoidance,” in *Proceedings of the Conference on Automotive Safety and Control*, 2014.
- [4] —, “A motivational driver steering model: Task difficulty homeostasis from a control theory perspective,” in *Proceedings of the Conference on Intelligent Transportation and Human Factors*, 2015.
- [5] A. Mazloumi, F. Gharagozlou, J. N. Saraji, A. Nahvi, M. Ashouri, and H. Mozaffari, “Estimating bus driver fatigue through performance measures in a virtual driving environment,” *Neuroscience Journal of Shefaye Khatam*, 2015.
- [6] H. Mozaffari, A. Dabiri, and K. Gu, “Bayesian investigation on the nonlinear estimation problem with delayed measurement,” Technical Report / Submitted to IEEE TAC, Tech. Rep., 2025.

TEACHING STATEMENT

Teaching students from diverse academic backgrounds has shown me that engineering education must evolve in parallel with emerging research directions and technological change. As both a researcher and instructor, I strive to create learning environments where students build rigorous analytical foundations, develop strong engineering judgment, and engage with workflows that reflect modern research and industry practice.

Teaching Philosophy. My instructional framework follows a consistent progression—motivation → problem framing → solution discovery → synthesis → dissemination of results. This mirrors how research problems are formulated, investigated, and communicated.

Motivation. I begin each course by situating the material within current engineering challenges and job-market skill needs. Students review how course topics relate not only to professional practice but also to emerging research areas in sensing, control, robotics, and computation. At the start of each topic, I revisit these connections to reinforce relevance and inspire curiosity.

Problem Framing. Students learn to articulate precise engineering and mathematical formulations of the problems addressed in each session. This transition from conceptual motivation to rigorous definition is essential in research-driven environments.

Solution Discovery. Before formal methods are introduced, students explore solution strategies through guided reasoning and partially completed notes. This inquiry-based approach trains them to analyze unfamiliar systems, evaluate alternatives, and understand the logic behind established methodologies.

Synthesis Through Research-Inspired Projects. Each class meeting concludes with conceptual synthesis, homework for reinforcement, and progress on a semester-long project. A representative example is a low-cost ultrasonic radar system developed in my Mechatronics course. Students carry out requirements analysis, sensor characterization, embedded design, communication protocols, system integration, and error evaluation under a strict \$30 budget. This iterative process reflects the structure of research projects: decomposition, implementation, integration, validation, and refinement.

Professional Dissemination. Students prepare technical reports, system documentation, and code repositories, which they publish on personal webpages and GitHub profiles. They present their results to peers, practicing skills essential for conferences, proposal development, and collaborative research.

Feedback and Inclusive Engagement. I cultivate an environment that supports equitable participation and intellectual risk-taking through weekly reflections, anonymous feedback,

and in-class diagnostics. This ensures that students with varying preparation levels can contribute meaningfully.

Summary. My goal is to develop students who are analytically strong, research-minded, and capable of connecting theory to impactful applications. I remain committed to integrating research advances into my teaching, supporting student growth, and preparing future engineers and researchers for a rapidly evolving technological landscape. R1

REFERENCES

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