Joe Payne

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INDUSTRIAL EXPERIENCE

Relativity Space Long Beach, CA

Senior Robotics Software Engineer 2024-2026

- Led development of the central architecture for a coordinated robotic manipulation repair platform
- Implemented data collection, merging, and feature recognition for a six unit LiDAR system
- Completed literature review to drive the technical direction of projects

Amazon Salt Lake City, UT

Software Development Engineer 2018

- Maintained and updated a service for managing internal language translation tasks
- Handled server outages with our customer-facing products as an on-call engineer
- Communicated directly with end users to prioritize and implement feature requests

EDUCATION

Carnegie Mellon University GPA: 4.0/4.0 Pittsburgh, PA

Doctor of Philosophy in Mechanical Engineering 2024

Selected Coursework: Optimal Control & Reinforcement Learning, Robot Dynamics & Analysis, Nonlinear Control

University of Michigan GPA: 3.95/4.0 Ann Arbor, MI

Bachelor of Science in Engineering in Computer Science, Mechanical Engineering, Dual Degree 2017

SKILLS

Programming Languages: C/C++, Python, Julia, MATLAB

Software: Git, Linux, LaTeX, Adobe Illustrator, Simulink

DOCTORAL RESEARCH

Carnegie Mellon University

Thesis: State Estimation Techniques for Hybrid Dynamical Systems 2018-2024

Optimal Estimation for Hybrid Systems

- Developed an iLQR-based algorithm for optimal state estimation through contact events utilizing the saltation matrix to obtain gradients of the value function
- Created generalized frameworks for hybrid system simulation and estimation using functional programming concepts in Julia to enable demonstration on any event driven hybrid system

Momentum Observer Based Contact Estimation for Bipedal Robots

- Developed an algorithm utilizing a collection of momentum observers with differing dynamic assumptions to enable active contact mode detection without force sensors on the feet
- Demonstrated the accuracy of the contact mode estimation on a 30 degree-of-freedom bipedal robotic system in simulation with MuJoCo and Simulink

Kalman Filtering for Uncertain Hybrid Systems

- Derived the uncertainty aware saltation matrix which linearizes hybrid transition events with structural uncertainty, such as varying ground height or unknown surface parameters
- Developed the Uncertainty Aware Salted Kalman Filter (uaSKF) using the uncertainty aware saltation matrix to update covariances through hybrid events, which reduced estimation error by up to 60%
- Wrote MATLAB simulations for a variety of systems, including an ASLIP-hopper to demonstrate the algorithm's effectiveness

ADDITIONAL GRADUATE RESEARCH

Kalman Filtering for Hybrid Dynamical Systems 2020-2021

- Co-developed the Salted Kalman Filter (SKF), which improves covariance propagation through hybrid events
- Demonstrated performance comparable to high count particle filters while running nearly 1000x faster

Simultaneous Localization and Mapping for Highly Dynamic Systems 2019-2021

- Co-developed the Periodic SLAM algorithm, which utilizes multiple factor graphs to achieve improved state estimation
- Utilized motion capture to demonstrate accurate results on trials where existing methods failed to provide estimates

A Flamingo Inspired Legged Robot 2019-2020

- Co-developed the Flamingobot, both mechanical and controller design
- Advised an undergraduate project to develop walking gaits utilizing reinforcement learning methods such as PPO

PUBLICATIONS

J. Joe Payne; James Zhu; Nathan J. Kong; and Aaron M. Johnson. Hybrid Iterative Linear Quadratic Estimation: Optimal Estimation for Hybrid Systems. IEEE Robotics and Automation Letters, 10: 3070–3077. 2025.

J. Joe Payne; Daniel A. Hagen; Denis Garagić; and Aaron M. Johnson. Multi-Momentum Observer Contact Estimation for Bipedal Robots. In arXiv:2412.03462 [cs.RO]. 2024. Under review

Nathan J. Kong; **J. Joe Payne**; James Zhu; and Aaron M. Johnson. Saltation Matrices: The Essential Tool for Linearizing Hybrid Dynamical Systems. Proceedings of the IEEE, 112: 585–608. June 2024.

James Zhu; **J. Joe Payne**; and Aaron M. Johnson. Convergent iLQR for Safe Trajectory Planning and Control of Legged Robots. In IEEE Intl. Conference on Robotics and Automation, pages 8051–8057, 2024.

J. Joe Payne; Nathan J. Kong; and Aaron M. Johnson. The Uncertainty Aware Salted Kalman Filter: State Estimation for Hybrid Systems with Uncertain Guards. In IEEE/RSJ Intl. Conference on Intelligent Robots and Systems (IROS), 2022.

Hans Kumar; **J. Joe Payne**; Matthew Travers; Aaron M. Johnson; and Howie Choset. Periodic SLAM: Using Cyclic Constraints to Improve the Performance of Visual-Inertial SLAM on Legged Robots. In IEEE Intl. Conference on Robotics and Automation (ICRA), 2022.

Nathan J. Kong; **J. Joe Payne**; George Council; and Aaron M. Johnson. The Salted Kalman Filter: Kalman Filtering on Hybrid Dynamical Systems. Automatica, 2021.

ABSTRACTS AND POSTERS

J. Joe Payne; and Aaron M. Johnson. Multiple Model State Estimation for Hybrid Dynamical Systems. In Dynamic Walking, June 2023.

J. Joe Payne; Nathan J. Kong; and Aaron M. Johnson. State Estimation for Hybrid Systems: Saltation Based Methods. In IROS Workshop on Agile Robotics, October 2022.

J. Joe Payne; Nathan J. Kong; and Aaron M. Johnson. Kalman Filtering for Hybrid Systems. In Dynamic Walking, June 2022.

Hans Kumar; **J. Joe Payne**; Matthew Travers; Aaron M. Johnson; and Howie Choset. Periodic SLAM: Using Cyclic Constraints to Improve the Performance of Visual-Inertial SLAM on Legged Robots. In ICRA Workshop on Visual-Inertial Navigation Systems, May 2021.

Edward Lu; Nathan J. Kong; **J. Joseph Payne**; and Aaron M. Johnson. Generating a Dynamic Controller for a Flamingo Inspired Robot using Deep Reinforcement Learning. In Dynamic Walking, May 2020.

J. Joe Payne; Nathan J. Kong; and Aaron M. Johnson. Flamingobot: a Flamingo Inspired Minimal Energy Standing Biped Robot. In Dynamic Walking, Canmore, Canada, June 2019.

TEACHING EXPERIENCE

Graduate Teaching Assistant *Dynamics* and *Dynamic Systems and Controls* Fall 2019, Winter 2021

- Ran weekly recitations and office hours for approximately 30 students (5.0/5.0 student evaluation)
- Wrote clearly understandable solution sheets for homeworks and exams
- Proctored and graded weekly quizzes
- Graded exams and ensured consistency in grading across all TAs

LEADERSHIP AND VOLUNTEER EXPERIENCE

Reviewer, IEEE Robotics and Automation Letters, ICRA, IROS 2020-Present

Mentor, Gwen's Girls 3D Printing and Robotics Programs 2021-2023

Session Chair, IEEE International Conference on Intelligent Robots and Systems 2022

President, University of Michigan Stand-Up Comedy Club 2015-2017

Local Trips Chair, University of Michigan Snowboard Club 2015-2017