J. Joe Payne

(248)229-0174 • j.joseph.payne@gmail.com • linkedin/jjoepayne • github/jjoepayne • jjoepayne.github.io

EDUCATION

Carnegie Mellon University GPA: 4.0/4.0 — Pittsburgh, PA

Doctor of Philosophy in Mechanical Engineering — Expected May 2024

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

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

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

SKILLS

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

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

Hardware: Microcontrollers, 3D Printing, Mill, Lathe, Soldering

DOCTORAL RESEARCH

Thesis: State Estimation Techniques for Hybrid Dynamical Systems — 2018-Present

Optimal Estimation for Hybrid Systems

- Developing an iLQR-based algorithm for optimal state estimation through contact events utilizing the saltation matrix to obtain gradients of the value function
- Creating generalized frameworks for hybrid system simulation and estimation using functional programming concepts in Julia to demonstrate performance on a variety of systems

Momentum Observer Based Contact Estimation for Bipedal Robots

- Developing an algorithm in MATLAB utilizing a collection of momentum observers with differing dynamic assumptions to enable active contact mode detection without force sensors on the feet
- Demonstrating 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 simulations in MATLAB for a variety of sample systems, including an ASLIP-hopper to demonstrate the effectiveness of the algorithm

ADDITIONAL 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

INDUSTRIAL EXPERIENCE

Amazon — Salt Lake City, UT

Software Development Engineer — January-August 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

Amazon Seattle, WA

Software Development Engineering Intern Summers 2016-2017

- Created a dynamic webpage enabling economists to more efficiently view sales data
- Created a data cleaning and machine learning pipeline utilizing Spark

Quantum Signal Saline, MI

Mechanical Engineering Intern Summer 2015

- Converted an ATV to allow for autonomous driving with a focus on gear shifting
- Designed a custom PCB to control a linear actuator enabling shifting
- Designed and tuned a controller to reliably reach desired gears

PUBLICATIONS

Nathan J. Kong; **J. Joe Payne**; James Zhu; and Aaron M. Johnson. Saltation Matrices: The Essential Tool for Linearizing Hybrid Dynamical Systems. arXiv:2306.06862 [cs.RO]. 2023. Under review

James Zhu; **J. Joe Payne**; and Aaron M. Johnson. Convergent iLQR for Safe Trajectory Planning and Control of Legged Robots. In arXiv:2304.00346 [cs.RO], 2023. Under review

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.

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.

ADDITIONAL 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