J. Joe Payne

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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 Computer Science, Mechanical Engineering, Dual Degree — December 2017

SKILLS

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

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

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

DOCTORAL RESEARCH

Carnegie Mellon University

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
- 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

- 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 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

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.

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