Noel Csomay-Shanklin

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Education

PhD	California Institute of Technology Control and Dynamical Systems	2019 – 2025
B.S.	Georgia Institute of Technology, Major: Mechanical Engineering Minors: Computer Science, Robotics GPA: 4.0/4.0	2015 – 2019

Research Projects

Predictive Control for Legged Systems

Collaborated on implementing a nonlinear model predictive controller for a planar biped [C$_9$] using the OCS2 predictive control toolbox, and experimentally investigated the importance of using properly designed running and terminal costs to the stability of the robotic system. Designed and implemented a geometrically consistent nonlinear model predictive controller for a 3D hopping robot [U$_2$], which was able to demonstrate stable hopping on hardware, and flipping and trajectory tracking in simulation. Future work includes implementation of predictive controllers on a lower body exoskeleton.

Hierarchical Control with Guarantees

Developed a hierarchical control architecture which integrates CLFs and MPC for robust state and input constrained nonlinear stabilization [C$_{11}$]. Future work includes theoretical extensions to systems with underactuation, as well as the incorporation of a high-level decision making layer.

Structured Use of Machine Learning in Robotic Systems

Generated neural network based feedback policies via neural ODEs, which rendered the underactuated states of a planar biped stable [C$_{10}$]. Leveraged user preferences to navigate the complex parameter space of gait generation [C$_6$] and gain tuning [C$_8$]. Learned the projection of model uncertainty onto barrier function certificates in order to achieve stepping stones on a planar biped [C$_5$]. Estimated uncertain mass parameters of legged robots online [J$_5$]. Performed walking parameter estimation for use with a robotic prosthetic device [J$_4$].

Behavior Generation for Legged Systems

Generated walking, trotting, and running behaviors for quadrupeds using coupled bipeds [J$_1$], and developed coupled Lyapunov function certificates of stability [J$_3$]. Applied this framework to quadrupedal walking up slopes [C$_4$]. Investigated the use of the saltation matrix for generating more robust walking gaits [U$_1$]. Worked towards generating a framework for verifying safety of motion primitives for legged systems [C$_7$].

Industry Experience

Control Systems Research Intern   2019
Disney Research, Mentor: Lanny Smoot
Developed control for an in-house omnidirectional treadmill, and was able to demonstrate stabilization of a spherical pendulum and an unactuated "walking" armature [C$_3$].

Controls and Autonomy Software Engineering Intern   2018
NASA Jet Propulsion Laboratory, Mentors: Alex Brinkman, Paul Backes
Implemented a force controller on a 3-DOF robotic arm in order to test sampling tool
geometries for a potential future mission to Enceladus, a moon of Saturn [C$_1$].

Funding and Grants

NSF Graduate Research Fellowship Program	2021 – 2024
3 years of full tuition and stipend support for PhD	
Kortschak Scholars Program	2019 – 2021
2 years of full tuition and stipend support for PhD	
President's Undergraduate Research Award	2017, 2018
2 terms of $1,500 funding for undergraduate research	
Summer Undergraduate Research Fellowship	2017
$6,000 of funding for summer undergraduate research	

Outreach

Lab Tours	2018 – Present
Over 10 tours and demos given to students from Kindergarten to community college level	
FIRST Robotics Mentor with Neighbors Empowering Youth	2021 – Present
Mentoring a community team of middle and high school students design and build a robot to compete in the FRC competition	
John Muir High School Engineering Week	February 2022
Discussed my research trajectory and experiences with 30 high school students pursuing careers in STEM, followed by a robot demo	
SURF Mentor	Summer 2022
Mentored a summer student with communication protocols and the application of MPC to hopping robots	
Rise Tutor	2020 – 2021
Tutored a high school student with algebra and calculus	

Academic Activities

REVIEWER	**Journals**
	Robotics and Automation Letters (RA-L)
	Control Systems Letters (L-CSS)
	Conferences
	International Conference on Robotics and Automation (ICRA)
	International Conference on Intelligent Robots and Systems (IROS)
	Conference on Control Technology and Applications (CCTA)
	American Control Conference (ACC)
	Conference on Decision and Control (CDC)

Awards and Recognition

Best Oral Paper Award Finalist (Humanoids, [C$_9$])	2022
Richard K. Whitehead Jr. Memorial Award	2019
In recognition of outstanding scholarship and service	
Goldwater Scholarship Honorable Mention	2019
Undergraduate Research Symposium College of Engineering Oral Presentation Third Place	2017
Dean's List (8 terms)	2015 – 2019

Teaching Experience

Nonlinear Control Teaching Assistant   2020 – Present
Caltech, Professor: Dr. Aaron Ames
Topics covered include: feedback linearization, outputs and zero dynamics, underactuation, control Lyapunov functions, Lyapunov backstepping, control barrier functions, robust nonlinear control, adaptive nonlinear control, and hybrid systems. Gave occasional lectures, held weekly recitations, and helped compose and grade exams.

Nonlinear Dynamics Teaching Assistant   2020 – Present
Caltech, Professor: Dr. Aaron Ames
Topics covered include: existence and uniqueness, comparison principles, linearizations, Lyapunov stability, invariance principles, input-to-state stability, barrier functions, periodic orbits, and Poincaré sections. Gave occasional lectures, held weekly recitations, and helped compose and grade exams.

Technical Skills

CODING	C++ (proficient), Matlab (proficient), Python (working), Labview (basic)
SOFTWARE	CMake, CVX, Solidworks, Mathematica, Mosek, ROS (basic)
MACHINING	3 axis CNC mill, manual lathe, waterjet, bandsaw, 3d printer, and most basic shop tools

Publications

Journals:

[J_6]   Y. Chen, U. Rosolia, W. Ubellacker, N. Csomay-Shanklin, A. D. Ames
Interactive Multi-Modal Motion Planning with Branch Model Predictive Control
IEEE Robotics and Automation Letters, 2022. [Paper]

[J_5]   Y. Sun, W. Ubellacker, W. Ma, X. Zhang, C. Wang, N. Csomay-Shanklin, M. Tomizuka, K. Sreenath, A. D. Ames
Online Learning of Unknown Dynamics for Model-Based Controllers in Legged Locomotion
IEEE Robotics and Automation Letters, 2021. [Paper]

[J_4]   J. Camargo, W. Flanagan, N. Csomay-Shanklin, B. Kanwar, A. Young
A Machine Learning Strategy for Locomotion Classification and Parameter Estimation using Fusion of Wearable Sensors
IEEE Transactions on Biomedical Engineering, 2021. [Paper]

[J_3]   W. Ma, N. Csomay-Shanklin, S. Kolathaya, K. A. Hamed, A. D. Ames
Coupled Control Lyapunov Functions for Interconnected Systems, with Application to Quadrupedal Locomotion
IEEE Robotics and Automation Letters, 2021. [Paper]

[J_2]   J. Camargo, A. Ramanathan, N. Csomay-Shanklin, A. Young
Automated Gap-Filling for Marker-Based Biomechanical Motion Capture Data
Computer Methods in Biomechanics and Biomedical Engineering, 2020.

[J_1]   W. Ma, N. Csomay-Shanklin, A. D. Ames
Coupled Control Systems: Periodic Orbit Generation with Application to Quadrupedal Locomotion
IEEE Control Systems Letters, 2020. [Paper]

Conferences:

[C$_{11}$] N. Csomay-Shanklin[†], A. J. Taylor[†], U. Rosolia, A. D. Ames
Multi-Rate Planning and Control of Uncertain Nonlinear Systems: Model Predictive Control and Control Lyapunov Functions
IEEE Conference on Decision and Control (CDC), 2022. [Paper][Talk]

[C$_{10}$] I. D. R. Jimenez[†], N. Csomay-Shanklin[†], A. D. Ames
Neural Gaits: Learning Bipedal Locomotion via Control Barrier Functions and Zero Dynamics Policies
Learning for Dynamics and Control Conference (L4DC), 2022. [Paper][Video]

[C$_9$] M. Y. Galliker[†], N. Csomay-Shanklin[†], R. Grandia, A. Taylor, F. Farshidian, M. Hutter, A. D. Ames
Planar Bipedal Locomotion with Nonlinear Model Predictive Control: Online Gait Generation using Whole-Body Dynamics
IEEE-RAS International Conference on Humanoid Robots (Humanoids), 2022. [Paper] [Video]

[C$_8$] N. Csomay-Shanklin, M. Tucker, M. Dai, J. Reher, A. D. Ames
Learning Controller Gains on Bipedal Walking Robots via User Preferences
IEEE International Conference on Robotics and Automation (ICRA), 2022. [Paper] [Video]

[C$_7$] W. Ubellacker, N. Csomay-Shanklin,T. G. Molnár, A. D. Ames
Verifying Safe Transitions Between Dynamic Motion Primitives on Legged Robots
IEEE/RSJ International Conference on Intelligent Robots ad Systems (IROS), 2021. [Paper][Video]

[C$_6$] M. Tucker, N. Csomay-Shanklin, W. Ma, A. D. Ames
Preference-Based Learning for User-Guided HZD Gait Generation on Bipedal Walking Robots
IEEE International Conference on Robotics and Automation (ICRA), 2021. [Paper] [Video] [Blog]

[C$_5$] N. Csomay-Shanklin[†], R. K. Cosner[†], M. Dai[†], A. J. Taylor, A. D. Ames
Episodic Learning for Safe Bipedal Locomotion with Control Barrier Functions and Projection-to-State Safety
Learning for Dynamics and Control Conference (L4DC), 2021. [Paper] [Video] [Blog]

[C$_4$] W. Ma, N. Csomay-Shanklin, A. D. Ames
Quadrupedal Robotic Walking on Sloped Terrains via Exact Decomposition into Coupled Bipedal Robots
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2020. [Paper] [Video]

[C$_3$] J. Reher, N. Csomay-Shanklin, D. L. Christensen, B. Bristow, A. D. Ames, L. Smoot
Passive Dynamic Balancing and Walking in Actuated Environments
IEEE International Conference on Robotics and Automation, 2020. [Paper][Video]

[C$_2$] E. Ambrose, N. Csomay-Shanklin, Y. Or, A. D. Ames
Design and Comparative Analysis of 1D Hopping Robots
IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2019. [Paper]

[C$_1$] M. Badescu, P. Backes, S. Moreland, A. Brinkman, D. Riccobono, M. Dotson, N. Csomay-Shanklin, S. Ubellacker, J. Molaro, M. Chouroun, G. Genta
Sampling Tool Concepts for Enceladus Lander In-Situ Analysis
IEEE Aerospace Conference (AeroConf), 2019. [Paper]

In Progress:

[U$_2$] N. Csomay-Shanklin, V. D. Dorobantu, A. D. Ames
Nonlinear Model Predictive Control of a 3D Hopping Robot: Leveraging Lie Group Integrators for Dynamically Stable Behaviors
Submitted to ICRA, 2023. [Preprint][Video]

[U$_1$] M. Tucker, N. Csomay-Shanklin, A. D. Ames
Robust Bipedal Locomotion: Leveraging Saltation Matrices for Gait Optimization
Submitted to ICRA, 2023. [Preprint][Video]

Presentations:

[P$_6$] **Multi-Rate Planning and Control of Uncertain Nonlinear Systems: Model Predictive Control and Control Lyapunov Functions**
CDC, December 2022

[P$_5$] **Bipedal Locomotion with Nonlinear Model Predictive Control: Online Gait Generation using Whole-Body Dynamics**
Dynamic Walking, June 2022

[P$_4$] **Preference-Based Learning for User-Guided HZD Gait Generation on Bipedal Walking Robots**
ICRA, 2022

[P$_3$] **Integrated Multi-Rate Control**
Rigorous Systems Research Group Meeting, July 2021

[P$_2$] **Fast Trajectory Generation for Quadrupedal Walking on Slopes**
Dynamic Waking, June 2021

[P$_1$] **Coupled Control Lyapunov Functions for Interconnected Systems, with Application to Quadrupedal Locomotion**
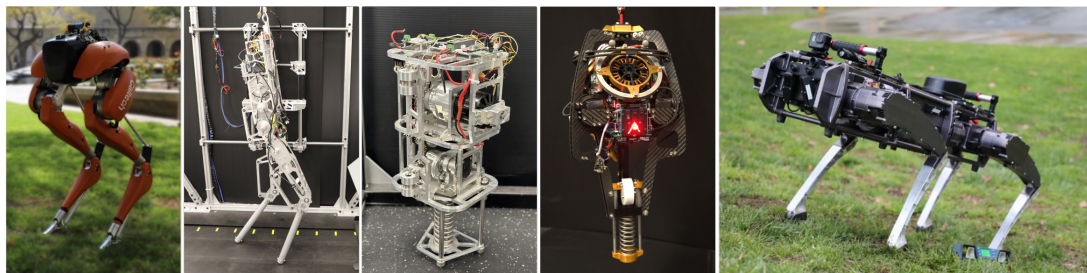*ICRA, May 2021*

PATENTS

J. Li, B. Kanwar, T. Johnson, J. Meditz, A. Yang, N. Csomay-Shanklin, J. Bishop, D. Molinaro, A. Young
Exosuit Support Systems and Methods
US 2022/0193887 A1

ROBOTS

Robotic platforms that I have worked on. Left to right: Cassie, AMBER-3M, 1D hopper, ARCHER, Vision 60.