Noel Csomay-Shanklin

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EDUCATION

PhD	CALIFORNIA INSTITUTE OF TECHNOLOGY	2019 − 2025
	Control and Dynamical Systems	

B.S.	GEORGIA INSTITUTE OF TECHNOLOGY,	2015 − 2019
	Major: Mechanical Engineering	
	Minors: Computer Science, Robotics	
	GPA: 4.0/4.0	

RESEARCH PROJECTS

Optimization-Based Control for Legged Systems

Collaborated on implementing a nonlinear whole-body 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 [C_{13}], which was able to demonstrate stable hopping on hardware, and flipping and trajectory tracking in simulation. Performed non-convex path planning on the hopping robot [C_{18}], and demonstrated significant runtime speedup by leveraging both the CPU and the GPU.

Hierarchical Autonomy with Guarantees

Developed a hierarchical control architecture which integrates Control Lyapunov Functions (CLFs) and Model Predictive Control (MPC) for robust state and input constrained nonlinear stabilization [C_{11}]. Leveraged these ideas to generate a provably feasible full-stack controller for underactuated systems [C_{19}].

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]. Explored using massively parallel simulation to learn dynamic error tracking tubes for safe path planning [C_{17}]. Imitation learned an optimal feedback policy for a 3D hopping robot that demonstrated exceptional robustness on hardware [C_{16}] [Video] and had provable guarantees [C_{15}]. Currently investigating the ways that diffusion can be used to amortize the computational cost of online optimal control [U_1].

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 [C_{12}]. Worked towards generating a framework for verifying safety of motion primitives for legged systems [C_7], [C_{14}].

Industry Experience

Research Intern   2023
Boston Dynamics AI Institute, Mentor: Farbod Farshidian
Investigated methods for combining MPC and RL to produce robust, precise locomotion for quadrupedal robots.

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 30 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** Automatica 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) Humanoids Conference Conference on Control Technology and Applications (CCTA) American Control Conference (ACC) Conference on Decision and Control (CDC)

Awards and Recognition

Outstanding Dynamics and Control Paper Award (ICRA, [C_{13}])	2023
Best Oral Paper Award Finalist (Humanoids, [C_9])	2022
Richard K. Whitehead Jr. Memorial Award *In recognition of outstanding scholarship and service*	2019
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 – 2023
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 – 2023
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	Modern 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_8] M. Cohen, N. Csomay-Shanklin, W. D. Compton, T. Molnar, A. D. Ames
Safety-Critical Controller Synthesis with Reduced-Order Models
Submitted to IEEE Control Systems Letters, 2025.

[J$_7$] I. Incer, N. Csomay-Shanklin, A. D. Ames, R. M. Murray
Layered Control Systems Operating on Multiple Clocks
IEEE Control Systems Letters, 2024. [Paper]

[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$_{19}$] N. Csomay-Shanklin, A. D. Ames
Bézier Reachable Polytopes: Efficient Certificates for Robust Motion Planning with Layered Architectures
Submitted to IEEE American Control Conference (ACC), 2025. [Paper]

[C$_{18}$] N. Csomay-Shanklin, W. D. Compton, A. D. Ames
Dynamically Feasible Path Planning in Cluttered Environments via Reachable Bézier Polytopes
Submitted to IEEE International Conference on Robotics and Automation (ICRA), 2025. [Video]

[C$_{17}$] W. D. Compton, N. Csomay-Shanklin, A. D. Ames
Dynamic Tube MPC: Learning Tube Dynamics with Massively Parallel Simulation for Robust Safety in Practice
Submitted to IEEE International Conference on Robotics and Automation (ICRA), 2025. [Video]

[C$_{16}$] N. Csomay-Shanklin*, W. D. Compton*, I. D. J. Rodriguez*, E. Ambrose, Y. Yue, A. D. Ames
Robust Agility via Learned Zero Dynamics Policies
IEEE International Conference on Intelligent Robots and Systems (IROS), 2024. [Paper][Video][Compilation Video]

[C$_{15}$] W. D. Compton*, I. D. J. Rodriguez*, N. Csomay-Shanklin*, Y. Yue, A. D. Ames
Constructive Nonlinear Control of Underactuated Systems via Zero Dynamics Policies
Conference on Decision and Control (CDC), 2024. [Paper]

[C₁₄] W. Ubellacker, N. Csomay-Shanklin, A. D. Ames
Approximating Regions of Attraction via Flow-Control Barrier Functions and Constrained Polytope Expansion
IEEE Americal Control Conference (ACC), 2024. [Paper]

[C₁₃] 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
IEEE International Conference on Robotics and Automation (ICRA), 2023. **Presented with the Outstanding Dynamics and Control Paper Award**. [Paper][Video]

[C₁₂] M. Tucker, N. Csomay-Shanklin, A. D. Ames
Robust Bipedal Locomotion: Leveraging Saltation Matrices for Gait Optimization
IEEE International Conference on Robotics and Automation (ICRA), 2023. [Paper][Video]

[C₁₁] 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]

[C₁₀] 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]

[C₉] 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]

[C₈] 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]

[C₇] 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]

[C₆] 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]

[C₅] 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]

[C₄] 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]

[C₃] J. Reher*, <u>N. Csomay-Shanklin</u>*, 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]

[C₂] E. Ambrose, <u>N. Csomay-Shanklin</u>, 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]

[C₁] M. Badescu, P. Backes, S. Moreland, A. Brinkman, D. Riccobono, M. Dotson, <u>N. Csomay-Shanklin</u>, 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:

[U₂] <u>N. Csomay-Shanklin</u>, A. D. Ames
Flipping With a 3D Hopping Robot
In preparation, 2025

[U₁] I. D. R. Jimenez, <u>N. Csomay-Shanklin</u>, W. D. Compton, A. D. Ames
Diffusion-Based Optimal Control
In preparation, 2025

Presentations:

[P₁₁] **Robust Agility via Learned Zero Dynamics Policies**
ICRA, Oct 2024

[P₁₀] **Learned Regions of Attraction for Safe Motion Primitive Transitions**
ICRA, Oct 2024

[P₉] **Approximating Regions of Attraction via Flow-Control Barrier Functions and Constrained Polytope Expansion**
ACC, July 2024

[P₈] **A Hierarchical Perspective on Control**
Neuromorphic Cognition Engineering Workshop, June 2023. MILA Robot Learning Seminar, November 2023. SIAM Student Seminar, November 2023.

[P₇] **Nonlinear Model Predictive Control of a 3D Hopping Robot: Leveraging Lie Group Integrators for Dynamically Stable Behaviors**
ICRA, June 2023

[P₆] **Multi-Rate Planning and Control of Uncertain Nonlinear Systems: Model Predictive Control and Control Lyapunov Functions**
CDC, December 2022

[P₅] **Bipedal Locomotion with Nonlinear Model Predictive Control: Online Gait Generation using Whole-Body Dynamics**
Dynamic Walking, June 2022

[P₄] **Preference-Based Learning for User-Guided HZD Gait Generation on Bipedal Walking Robots**
ICRA, 2022

[P₃] **Integrated Multi-Rate Control**
Rigorous Systems Research Group Meeting, July 2021

[P₂] **Fast Trajectory Generation for Quadrupedal Walking on Slopes**
Dynamic Waking, June 2021

[P₁] **Coupled Control Lyapunov Functions for Interconnected Systems, with Application to Quadrupedal Locomotion**
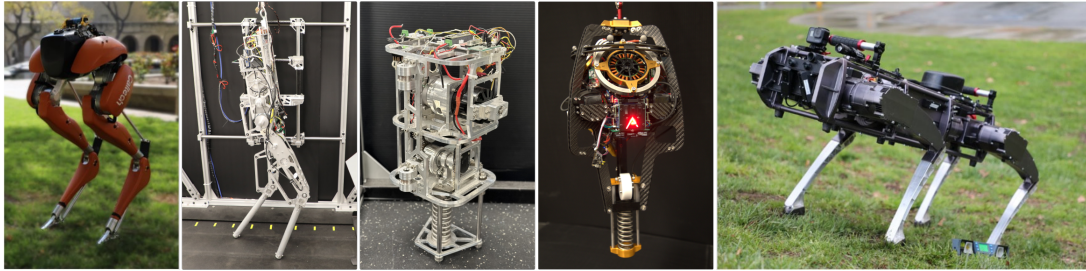*ICRA, May 2021*

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.