

William A Clark

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Research Interests

My research focus is on using geometry and dynamics to study mechanical systems with applications to robotics.

Geometric Mechanics

Lagrangian/Hamiltonian/Nonholonomic systems and their stability and control.

Hybrid Systems

Stability and invariants in hybrid and impact systems with applications to the Zeno phenomenon.

Robotic Perception

Geometric and gradient methods for aligning data for pose estimation.

Education

University of Michigan

Ph.D., Applied and Interdisciplinary Mathematics, 2020.

Dissertation: *Invariant Measures, Geometry, and Control of Hybrid and Nonholonomic Dynamical Systems*

Advisors: Anthony Bloch & Jessy Grizzle

Ohio University

B.S., Mechanical Engineering, magna cum laude, 2015.

Employment

Cornell University

2020 to present

Visiting Assistant Professor and NSF Postdoctoral Associate

Department of Mathematics

Mentors: Alexander Vladimirovsky & Steven Strogatz

Honors and Awards

1. Peter Smereka Thesis Award, University of Michigan, 2021
2. Outstanding Research Award, Mechanical Engineering Department, Ohio University, 2015
3. Member of Tau Beta Pi – The Engineering Honors Society, 2013–2015
4. Gateway Excellence Scholar, Ohio University, 2011–2015

Instruction

Cornell University

1. Instructor, Dynamical Systems (Math 6260), Fall 2020

2. Instructor, Calculus II (Math 1120), Spring 2021
3. Instructor, Differential Equations & Dynamical Systems (Math 4200), Fall 2021
4. Instructor, Partial Differential Equations (Math 4280), Spring 2022
5. Instructor, Introduction to Differential Equations (Math 3230), Fall 2022

University of Michigan

1. Instructor, Calculus I (Math 115), Fall 2015
2. Instructor, Calculus I (Math 115), Winter 2016
3. Instructor, Calculus I (Math 115), Fall 2016
4. Instructor, Calculus I (Math 115), Spring 2017
5. Instructor, Calculus II (Math 116), Fall 2017
6. Instructor, Calculus II (Math 116), Fall 2018
7. Instructor, Calculus I (Math 115), Spring 2019

Preprints and Research Notes

1. T.Y. Lin, W. Clark, R.M. Eustice, J.W. Grizzle, A. Bloch and M. Ghaffari, *Adaptive Continuous Visual Odometry from RGB-D Images*, [arXiv:1910.00713v1](#) [cs.RO].
2. W. Clark and A. Bloch. *Existence of Invariant Volumes in Nonholonomic Systems*, [arXiv:2009.11387v2](#) [math.DS], under review.
3. W. Clark and M. Ghaffari. *A Path-Dependent Variational Framework for Incremental Information Gathering*, [arXiv:2010.13813v1](#) [cs.RO].
4. W. Clark and A. Bloch. *Invariant Forms in Hybrid and Impact Systems and a Taming of Zeno*, [arXiv:2101.11128](#) [math.DS], under review.
5. W. Clark, M. Oprea, and A.J. Graven. *A Geometric Approach to Optimal Control of Hybrid and Impulsive Systems*, [arXiv:2111.11645](#) [math.OC], under review.
6. J. Kulik, D. Savransky, and W. Clark. *Fast Approximation of Continuous Thrust Optimal Relative Control in the Three Body Problem*, under review.

Refereed Journal Publications

1. A. Ahn, W. Clark, S. Nitzan and J. Sullivan. *Density of Gabor Systems Via the Short Time Fourier Transform*, *Journal of Fourier Analysis and Applications*. Vol 24 (3), pp. 699-718, 2018.
2. W. Clark, A. Bloch, L. Colombo and P. Rooney. *Time-minimum control of quantum purity for 2-level Lindblad equations*, *Discrete & Continuous Dynamical Systems-S*. Vol 13 (4), pp. 1061–1073, 2020.
3. W. Clark, A. Bloch and L. Colombo. *A Poincaré–Bendixson theorem for hybrid systems*, *Mathematical Control & Related Fields*. Vol 10 (1), pp. 27–45, 2020.
4. W. Clark and A. Bloch. *A Poincaré–Bendixson theorem for hybrid systems on directed graphs* *Mathematics of Control, Signals, and Systems*. Vol 32 (1), pp. 1-18, 2020.
5. W. Clark, M. Ghaffari and A. Bloch. *Nonparametric Nonparametric Continuous Sensor Registration*, *Journal of Machine Learning Research*. Vol 22, pp. 1–50, 2021.

6. J. -K. Huang, W. Clark and J.W. Grizzle. *Optimal Target Shape for LiDAR Pose Estimation*, IEEE Robotics and Automation Letters, Vol 7 (2), pp. 1238–1245, 2022.
7. W.A. Clark, M.W. Gomes, A. Rodriguez-Gonzalez, L.C. Stein and S.H. Strogatz, *Surprises in a classic boundary-layer problem*, [arXiv:2107.11624 \[math.CA\]](https://arxiv.org/abs/2107.11624), to appear.

Refereed Conference Proceedings

1. L. Colombo, A. Bloch and W. Clark. *Quasivelocities and Symmetries in Simple Hybrid Systems*, Proc. CDC, 2017.
2. W. Clark, A. Bloch, L. Colombo and P. Rooney. *Optimal Control of Quantum Purity $n = 2$ Systems*, Proc. CDC, 2017.
3. L. Colombo, A. Bloch and W. Clark. *Optimal time reversal symmetries and zero dynamics for simple hybrid Hamiltonian control systems*, Proc. ACC, 2018.
4. W. Clark and A. Bloch. *Stable orbits for a simple passive walker experiencing foot slip*, Proc. CDC, 2018.
5. M. Ghaffari, W. Clark, A. Bloch, R. Eustice and J. Grizzle. *Continuous Direct Sparse Visual Odometry from RGB-D Images*, Proc. RSS, 2019.
6. W. Clark and A. Bloch. *The Bouncing Penny and Nonholonomic Impacts*, Proc. CDC, 2019.
7. R. Zhang, T.Y. Lin, C.E. Lin, S.A. Parkison, W. Clark, J.W. Grizzle, R.M. Eustice and M. Ghaffari. *A New Framework for Registration of Semantic Point Clouds from Stereo and RGB-D Cameras*, 2021 IEEE International Conference on Robotics and Automation.
8. W. Clark and M. Oprea. *Optimal Control of Hybrid Systems via Hybrid Lagrangian Submanifolds*, 7th IFAC Workshop of Lagrangian and Hamiltonian Methods for Nonlinear Control, 2021.
9. S. Teng, D. Chen, W. Clark, and M. Ghaffari. *An Error-State Model Predictive Control on Connected Matrix Lie Groups for Legged Robot Control*, Proc. IROS 2022. [arXiv:2203.08728v1 \[cs.R0\]](https://arxiv.org/abs/2203.08728v1), to appear.
10. M. Oprea and W. Clark. *How do we walk? Using hybrid holonomy to approximate nonholonomic systems*, Proc. CDC, 2022. [arXiv:2203.16425 \[math.DG\]](https://arxiv.org/abs/2203.16425), to appear.
11. W. Clark and D. Kassabova. *Orientation Control of the Bouncing Ball*, Proc. CDC, 2022. [arXiv:2203.12688 \[math.OC\]](https://arxiv.org/abs/2203.12688), to appear.
12. S. Teng, W. Clark, A. Bloch, R. Vasudevan, and M. Ghaffari. *Lie Algebraic Cost Function Design for Control on Lie Groups*, Proc. CDC, 2022. [arXiv:2204.09177 \[math.OC\]](https://arxiv.org/abs/2204.09177), to appear.

Departmental Talks

1. *Continuous Direct Sparse Visual Odometry from RGB-D Images*, Student AIM Seminar, University of Michigan, Ann Arbor, Michigan (April 2019)
2. *Continuous Sensor Registration*, Invited Lecturer for NAVARCH 568, University of Michigan, Ann Arbor, Michigan (April 2019)
3. *The Bouncing Penny and Nonholonomic Impacts*, Student AIM Seminar, University of Michigan, Ann Arbor, Michigan (October 2019)
4. *Invariant Measures, Geometry, and Control of Hybrid and Nonholonomic Dynamical Systems*, KOD*LAB, University of Pennsylvania, Philadelphia, Pennsylvania (April 2020)

5. *Nonholonomic Systems are Weird*, Applied Dynamics Seminar, Cornell University, Ithaca, New York (August 2020)
6. *A Path-Dependent Variational Framework for Incremental Information Gathering*, Applied Dynamics Seminar, Cornell University, Ithaca, New York (October 2020)
7. *Geometry of Impacts*, Applied Dynamics Seminar, Cornell University, Ithaca, New York (February 2021)
8. *Geometry of Impact and Nonholonomic Systems*, Peter Smereka Thesis Award, University of Michigan, Ann Arbor, Michigan (February 2021)
9. *Continuous Direct Sparse Visual Odometry from RGB-D Images*, Geometry, Mechanics and Control Seminar, ICMAT, Madrid, Spain (March 2021)
10. *Energy and Volume-preservation are independent*, Applied Dynamics Seminar, Cornell University, Ithaca, New York (October 2021)
11. *The Shadowing Lemma*, Applied Dynamics Seminar, Cornell University, Ithaca, New York (December 2021)
12. *Isochrons: What are they and how do we compute them?*, Applied Dynamics Seminar, Cornell University, Ithaca, New York (February 2022)

Conference Presentations

1. *Time minimal control for a quantum Hamiltonian under Lindblad dissipation*, 11th Young Researcher Workshop on Geometry, Mechanics and Control, University of La Laguna, Tenerife, Spain. (January 2017)
2. *Optimal Control of Quantum Purity for $n = 2$ Systems*, 56th IEEE Conference on Decision and Control, Melbourne, Australia. (December 2017)
3. *Stable Orbits for a Simple Passive Walker Experiencing Foot Slip*, 57th IEEE Conference on Decision and Control, Miami Beach, Florida, USA. (December 2018)
4. *The Bouncing Penny and Nonholonomic Impacts*, 58th IEEE Conference on Decision and Control, Nice, France. (December 2019)
5. *Optimal Control of Hybrid Systems via Hybrid Lagrangian Submanifolds*, 7th IFAC Workshop of Lagrangian and Hamiltonian Methods for Nonlinear Control, 2021.
6. *Dynamics of Nonholonomic Billiards*, Dynamics Days, 2022.

Outreach Activities

Science Communications Fellow

2019

Partnered with the University of Michigan Museum of Natural History to promote appreciation and understanding of scientific research to the public.

Math Explorers Club

2020–present

Participated in weekend workshops for middle and high school students to cover mathematics not usually covered in K-12 curriculum.

Attendances

1. 11th Young Researcher Workshop on Geometry, Mechanics and Control, University of La Laguna, Tenerife, Spain. (January 2017)

2. V Iberoamerican meeting on geometry, mechanics and control, University of La Laguna, Tenerife, Spain. (January 2017)
3. 56th IEEE Conference on Decision and Control (CDC), Melbourne, Australia. (December 2017)
4. From Symplectic Geometry to Chaos, MSRI Summer Graduate School, Berkeley, CA, USA (Summer 2018)
5. 57th IEEE Conference on Decision and Control (CDC), Miami Beach, Florida, USA. (December 2018)
6. Robotics Science and Systems (RSS), Freiburg im Breisgau, Germany. (June 2019)
7. Séminaire de Mathématiques Supérieures 2019: Current Trends in Symplectic Topology, Centre de Recherches Mathématiques, Université de Montréal, Montréal, QC, Canada (Summer 2019)
8. 58th IEEE Conference on Decision and Control (CDC), Nice, France. (December 2019)
9. 7th IFAC Workshop of Lagrangian and Hamiltonian Methods for Nonlinear Control, 2021.
10. Dynamics Days 2022.

Professional Service

Scholarly Review

Nonlinear Analysis: Hybrid Systems
 Leibniz Transactions on Embedded Systems
 IEEE Robotics and Automation Letters
 IEEE Transactions on Automatic Control
 International Conference on Robotics and Automation (ICRA)
 Conference on Decision and Control (CDC)
 Communications in Nonlinear Science and Numerical Simulation
 Nonlinear Dynamics

Departmental Service

Cornell Research Experience for Undergraduates

Summer 2022

Organized an eight-week NSF-funded research experience for undergraduates (REU) in mathematics at Cornell University. Mentored four students in the project “Nonintegrable Constraints in Mechanics.” They obtained results in hybrid Lie-Poisson reduction and on the hybrid Perron-Frobenius operator.

Team members:

- *Maria Oprea (Graduate Student Assistant), Center of Applied Mathematics, Cornell University*
- *Robi Huq, University of Colorado Boulder*
- *Kaito Iwasaki, Ohio Wesleyan University*
- *Dora Kassabova, Cornell University*
- *Aden Shaw, Rose-Hulman Institute of Technology*

Applied Dynamics Seminar

2022–present

Organized the graduate student/postdoc Applied Dynamics Seminar at Cornell University.

Cornell Mathematical Contest in Modeling

Fall 2021, Fall 2022

Member of the Cornell University Math Modeling Committee. Assisted in problem formulation, provided feedback on submissions, and served as a contest judge.

Undergraduate Independent Research/Reading

1. *Andrew Graven, Independent Reading (Math 4901, Spring 2021)*
Geometric mechanics
2. *Javier Diaz, Independent Research (Math 4900, Fall 2021)*
Bifurcations of a bead on a flexible rotating hoop. Co-led with Dr. Andy Borum.
3. *Dora Kassabova, Independent Research (Math 4900, Spring 2022)*
Controllability of symmetric hybrid systems
Optimal control through intermittent contacts