CURRICULUM VITAE

MATTHEW D. KVALHEIM January 8, 2024

EDUCATION

Ph.D.	2018	University of Michigan, Electrical Engineering
M.S.	2017	University of Michigan, Mathematics
M.S.	2017	University of Michigan, Electrical Engineering
B.S.	2013	Ohio University, Electrical Engineering, #1 EECS graduate, GPA: 3.98, *Summa cum laude*

Experience in Higher Education

Aug 2023 – present	University of Maryland Baltimore County, Assistant Professor, Department of Mathematics and Statistics
Aug 2022 – June 2023	University of Michigan, Postdoctoral Assistant Professor Department of Mathematics
Aug 2019 – Aug 2022	University of Pennsylvania, Postdoctoral Researcher Department of Electrical and Systems Engineering
Sep 2018 – Aug 2019	University of Michigan, Postdoctoral Research Fellow

Honors Received:

2013	*Rackham Engineering Award (a graduate research fellowship)* University of Michigan, Rackham Graduate School
2013	*Outstanding Senior in Electrical Engineering* Ohio University, Department of Electrical Engineering and Computer Science
2013	*First Place, Undergraduate Student Expo* Ohio University
2012	*Undergraduate Research Award* Ohio University, College of Engineering
2012	*Outstanding Junior in Electrical Engineering* Ohio University, Department of Electrical Engineering and Computer Science
2011	*Dean's Scholarship* Ohio University, Department of Electrical Engineering and Computer Science
2011	*Fritz and Dolores Russ Scholarship* Ohio University, Department of Electrical Engineering and Computer Science
2009–2013	*Gateway Excellence Scholarship* Ohio University

Publications:

Peer-Reviewed Works:

Articles:

1. J. Welde, M. D. Kvalheim, and V. Kumar, "A compositional approach to certifying the almost global asymptotic stability of cascade systems", *IEEE Control Systems Letters*, 7 (2023), pp. 1969–1974.

2. Yu. Baryshnikov and M. D. Kvalheim, "Flux in tilted potential systems: negative resistance and persistence", *Communications in Mathematical Physics*, 400.2 (2023), pp. 853–930.

3. M. D. Kvalheim, "Obstructions to asymptotic stabilization", *SIAM J. Control and Optimization*, 61.2 (2023), pp. 536–542.

4. M. D. Kvalheim, "A generalization of the Hopf degree theorem", *Proceedings of the American Mathematical Society*, 151.1 (2023), pp. 453–454.

5. K. Chakraborty, H. Hu, M. D. Kvalheim, and F. Qian, "Planning of obstacle-aided navigation for multi-legged robots using a sampling-based method over directed graphs", *IEEE Robotics and Automation Letters*, 7.4 (2022), pp. 8861–8868.

6. M. D. Kvalheim and D. E. Koditschek, "Necessary conditions for feedback stabilization and safety", *J. Geometric Mechanics*, 14.4 (2022), pp. 659–693.

7. M. D. Kvalheim and A. M. Bloch, "Families of periodic orbits: closed 1-forms and global continuability", *J. Differential Equations*, 285 (2021), pp. 211–257.

8. M. D. Kvalheim, P. Gustafson, and D. E. Koditschek, "Conley's fundamental theorem for a class of hybrid systems", *SIAM J. Applied Dynamical Systems*, 20.2 (2021), pp. 784–825.

9. M. D. Kvalheim and S. Revzen, "Existence and uniqueness of global Koopman eigenfunctions for stable fixed points and periodic orbits", *Physica D*, 425 (2021), pp. 132959.

10. M. D. Kvalheim, B. Bittner, and S. Revzen, "Gait modeling and optimization for the perturbed Stokes regime", *Nonlinear Dynamics*, 97.4 (2019), pp. 2249–2270.

11. J. Eldering, M. D. Kvalheim, and S. Revzen, "Global linearization and fiber bundle structure of invariant manifolds", *Nonlinearity*, 31.9 (2018), pp. 4202–4245

Conference Proceedings:

1. J. Welde, M. D. Kvalheim, and V. Kumar, "The role of symmetry in constructing geometric flat outputs for free-flying robotic systems", *2023 IEEE International Conference on Robotics and Automation* (2023), pp. 12247-12253.

2. M. D. Kvalheim, D. A. Hong, and S. Revzen, "Generic properties of Koopman eigenfunctions for stable fixed points and periodic orbits", *IFAC-PapersOnline*, 54.9 (2021), pp. 267–272.

3. S. Revzen and M. D. Kvalheim, "Data-driven models of legged locomotion", *Micro-and Nanotechnology Sensors, Systems, and Applications VII*, 9467 (2015).

Non-Peer-Reviewed Works:

Chapters in Books:

1. M. D. Kvalheim and S. Revzen, "Bioinspired legged locomotion", chapter 3.2, "Templates and anchors", *Butterworth-Heinemann, Elsevier*, Oxford (2017).

2. M. D. Kvalheim and S. Revzen, "Bioinspired legged locomotion", chapter 3.5, "Locomotion as an oscillator", *Butterworth-Heinemann, Elsevier*, Oxford (2017).

Doctoral Thesis:

1. M. D. Kvalheim, "Aspects of invariant manifold theory and applications", *University of Michigan* (2018).

Preprints:

1. M. D. Kvalheim, "Relationships between necessary conditions for feedback stabilizability", *arXiv:2312.16752* (2023).

2. M. D. Kvalheim and E. D. Sontag, "Why do autoencoders work?", *arXiv:2310.02250* (2023).

3. M. D. Kvalheim and P. Arathoon, "Linearizability of flows by embeddings", *arXiv:2305.18288* (2023).

4. P. Arathoon and M. D. Kvalheim, "Koopman embedding and super-linearization counterexamples with isolated equilibria", *arXiv:2306.15126* (2023).

5. S. Wilshin, M. D. Kvalheim, C. Scott, and S. Revzen, "Estimating phase from observed trajectories using the temporal 1-form", *arXiv:2203.04498* (2022).

6. M. D. Kvalheim, P. Gustafson, and S. A. Burden, "A pasting lemma for Lipschitz functions", *arXiv:2109.08209* (2021).

7. S. Wilshin, M. D. Kvalheim, and S. Revzen, "Phase response curves and the role of coordinates", *arXiv:2111.06511* (2021).

8. M. D. Kvalheim, "Poincaré-Hopf theorem for hybrid systems", arXiv:2108.07434 (2021).

9. M. D. Kvalheim and S. Revzen, "Reverse-engineering invariant manifolds with asymptotic phase", arXiv:1608.08442 (2016).

Presentations:

Invited Talks:

1. M. D. Kvalheim and P. Arathoon, "Linearizability of dynamical systems by embeddings", *Joint Mathematics Meetings*, San Francisco, CA, USA (2023).

2. "Discovering engineering (im)possibilities with geometry and topology", *Johns Hopkins University Applied Physics Laboratory*, Baltimore, MD, USA.

3. "Discovering engineering (im)possibilities with geometry and topology", *University of Pennsylvania, GRASP Laboratory*, Philadelphia, PA, USA (2023).

4. "Asymptotic stabilizability", *Banff Internation Research Station*, Banff, AB, Canada (2023).
5. "Existence and uniqueness of Koopman eigenfunctions near stable equilibria and limit cycles", *International Symposium on Nonlinear Theory and Its Applications*, online (2022).
6. "Negative resistance in small-noise dynamics via persistent homology", *Indian Institute of Technology Bombay*, online (2022).
7. "Nonlinear systems", *University of Michigan*, Ann Arbor, MI (2022).
8. "Large deviations, persistent homology, and Brownian conductors with negative resistance", *Cornell University*, Probability Seminar, online (2022).
9. "When can hybrid systems operate safely?", *University of Michigan*, Control Seminar, online (2022).
10. "Flux in small noise dynamics: persistence and negative resistance", *Brown University*, Division of Applied Mathematics, online (2022).
11. "Flux in small noise dynamics: negative resistance and persistence", *University of Illinois Urbana-Champaign*, Mathematical Biology Seminar, online (2021).
12. S. A. Burden and M. D. Kvalheim, "When and how are hybrid dynamical systems conjugate to their classical quotients?", *SIAM Conference on Control and its Applications*, Minisymposium: Physically grounded semantics for programming hybrid dynamical systems, online (2021).
13. D. E. Koditschek, P. Gustafson, and M. D. Kvalheim,"Toward a physically grounded type theory for robot task composition", *IEEE International Conference on Robotics and Automation*, online (2021).
14. M. D. Kvalheim and Yu. Baryshnikov, "Small noise dynamics, persistence, and negative resistance", *SIAM Conference on Applications of Dynamical Systems*, Minisymposium: Stochastic oscillators, online (2021).
15. "Flux in tilted potential systems: negative resistance and persistence", Army Research Office SLICE MURI W911NF-18-1-032 Group Meeting.
16. "Towards a Conley theory for hybrid dynamical systems", *Rutgers University*, RIPODS/DATA-INSPIRE Workshop: Dynamics, Topology, and Robotic Control, online (2021).
17. "Hierarchical composition via collapse of dimension in dynamical systems", *ETH Zürich*, Series: Autonomy Talks, online (2021).
18. "Existence and uniqueness of global linearizing coordinates", *Army Research Lab*, online (2021).
19. "Safety and stabilization: necessary conditions", *Army Research Office SLICE MURI W911NF-18-1-032 Group Meeting*, online (2021).
20. "Proving periodic orbits exist: global continuation and Lyapunov 1-forms", *University of Pennsylvania*, GRST Seminar, online (2020).

21. A. M. Bloch and M. D. Kvalheim, "Geometry and dynamics of circulant systems", AMS sectional meeting, Special session: Geometric dynamics, online (2020).

22. Conley's fundamental theorem for a class of hybrid systems, *University of Pennsylvania*, Kod*Lab Research Seminar, online (2020).

23. "Toward a task planning theory for robot hybrid dynamics", *Casa Matemática Oaxaca*, online (2020).

24. M. D. Kvalheim, S. Wilshin, C. Scott, and S. Revzen, "Isochrons from short, noisy data", *Dynamics Days Europe*, Minisymposium: Stochastic oscillators, online (2020).

25. "Invariant manifolds, locomotion, and the Koopman operator", *University of Pennsylvania*, Chaudhari research group, Philadelphia, PA, USA (2019).

26. "Templates, anchors, and normally hyperbolic invariant manifolds", *University of Pennsylvania*, DAIR Lab Research Seminar, Philadelphia, PA, USA (2019).

27. 'Templates, anchors, and normally hyperbolic invariant manifolds", *University of Pennsylvania*, ScalAR Lab Research Seminar, Philadelphia, PA, USA (2019).

28. "Existence and uniqueness of linearizing semiconjugacies for stable fixed points and periodic orbits", *California Institute of Technology*, Army Research Office MURI 911NF-17-1-0306 Group Meeting, Pasadena, CA, USA (2019).

29. A. M. Bloch and M. D. Kvalheim, "Dynamics of circulant systems of ODEs", *SIAM Conference on Applications of Dynamical Systems*, Snowbird, UT, USA (2019).

30. M. D. Kvalheim and S. Revzen, "Reduced-order models for locomotion in the perturbed Stokes regime", *SIAM Conference on Applications of Dynamical Systems*, Snowbird, UT, USA (2019).

31. S. Revzen and M. D. Kvalheim, "Hybrid oscillators: phase and amplitude in a class of non-smooth systems", *SIAM Conference on Applications of Dynamical Systems*, Snowbird, UT, USA (2019).

32. "Aspects of invariant manifold theory and applications", *University of California Santa Barbara*, Army Research Office MURI 911NF-17-1-0306 Group Meeting, Santa Barbara, CA, USA (2019).

33. "Oscillators, asymptotic phase, and reduction of dynamical systems", *University of Michigan*, Applied and Interdisciplinary Mathematics Student Seminar, University of Michigan, Ann Arbor, MI, USA (2019).

34. "Invariant manifolds, asymptotic phase, and data-driven algorithms", *University of Pennsylvania*, Kod*Lab Research Seminar, Philadelphia, PA, USA (2018).

35. "A recipe for embedding templates in anchors", *University of Michigan*, Legged Robotics Seminar, Ann Arbor, MI, USA (2016).

36. "Introduction to homology: towards topological data analysis, pt. II", *University of Michigan*, Signal Processing Student Seminar, Ann Arbor, MI, USA (2015).

37. "Introduction to homology: towards topological data analysis, pt. I", *University of Michigan*, Signal Processing Student Seminar, Ann Arbor, MI, USA (2015).

Other Talks:

1. J. Welde, M. D. Kvalheim, and V. Kumar, "A compositional approach to certifying the almost global asymptotic stability of cascade systems", *IEEE International Conference on Robotics and Automation*, London, UK (2023).
2. J. Welde, M. D. Kvalheim, and V. Kumar, "A principal bundle perspective on differential flatness in complex robotic and biological systems", *Americal Physical Society March Meeting*, Las Vegas, Nevada, USA (2023).
3. S. Revzen, G. Council, and M. D. Kvalheim, "Is legged locomotion almost smooth?", Dynamic Walking, Calgary, AB, Canada (2019).
4. M. D. Kvalheim and S. Revzen, "Testing an extended 'Posture Principle"', *Annual meeting of the Society for Integrative and Comparative Biology*, San Francisco, CA, USA (2018).
5. M. D. Kvalheim and S. Revzen, "Phase-based models of rhythmic systems", *Dynamic Walking*, Columbus, OH, USA (2015).
6. S. Revzen and M. D. Kvalheim, "Better models of rhythmic systems: predicting locomotion from phase alone", *Annual meeting of the Society for Integrative and Comparative Biology*, *Dynamic Walking*, West Palm Beach, FL (2015).
7. S. Revzen. S. A. Burden, and M. D. Kvalheim, "Why the trot?", *Annual meeting of the Society for Integrative and Comparative Biology*, Austin, TX, USA (2014).

Posters:

1. J. Welde, M. D. Kvalheim, and V. Kumar, *IEEE International Conference on Robotics and Automation*, London, UK (2023).
2. H. Hu, M. Joyce, S. Wilshin, A. Spence, and F. Qian, "A mode map representation to predict steady states and attraction basins for legged locomotion on obstacle terrains", *International Conference on Intelligent Robotics and Systems*, Workshop: Robotics-inspired biology, online (2020).
3. M. D. Kvalheim and S. Revzen, "Principal Koopman eigenfunctions for nonlinear and nonsmooth systems", *University of California, Los Angeles*, Workshop: Operator theoretic methods in dynamic data analysis and control, Los Angeles, CA, USA (2019).
4. M. D. Kvalheim, J. Eldering, and S. Revzen, "Global linearization and fiber bundle structure of invariant manifolds", *AIMS Conference Series on Dynamical Systems and Differential Equations*, Taipei, Taiwan (2018).
5. M. D. Kvalheim and S. Revzen, "Templates and Anchors: a review of notions of model reduction", *Dynamic Walking*, Pensicola, FL, USA (2018).
6. M. D. Kvalheim and S. Revzen, "Asymptotic phase, model reduction, and control of Templates & Anchors", *Ohio State University*, Mathematical Biosciences Institute, Workshop: Sensorimotor control of animals and robots, Columbus, OH (2017).

7. M. D. Kvalheim and S. Revzen, "A dynamical systems perspective on Templates & Anchors: some general methods for anchoring templates", *IEEE/RSJ International Conference on Intelligent Robots and Systems*, Vancouver, BC, Canada (2017).

8. M. D. Kvalheim and S. Revzen, "Phase-based algorithm for modeling time-rescaling distortion of rhythmic data", *University of Michigan*, Engineering Graduate Symposium, Ann Arbor, MI, USA (2014).

9. M. D. Kvalheim and S. Revzen, "A hybrid system provides a robust alternative to a linear regulator", *University of Michigan*, Engineering Graduate Symposium, Ann Arbor, MI, USA (2013).

10. J. Belzer, R. Kollar, M. D. Kvalheim, M. Miltner, and C. Moore, "An indoor navigation device for use in GPS-denied environments", *Ohio University Student Expo*, Athens, OH (2013).

Service:

University Service:

2023–2024	UMBC Invitational Science Olympiad Co-organizer and Volunteer
2022	Females Excelling More in Math, Engineering, and Science (F.E.M.M.E.S.) Volunteer

Departmental Service:

2023–present	Pi Mu Epsilon Chapter Co-adviser
2019	Philly Robotics Expo (PRX) Volunteer
2015	University of Michigan Engineering Graduate Symposium Volunteer
2015	University of Michigan Graduate Student Council Panel Volunteer
2014	Volunteer for Robotics Demonstrations at Bryant Elementary School, Ann Arbor, MI

Service to the Profession:

- Associate Editor, *Mathematics of Control, Signals, and Systems* (2023–).
- Co-organizer for:
  - IEEE International Conference on Robotics and Automation, Workshop: "Compositional Robotics: Mathematics and Tools" (2023).
  - Festschrift in honor of Daniel E. Koditschek (2022).
  - IEEE International Conference on Robotics and Automation, Workshop: "Compositional Robotics: Mathematics and Tools" (2022).
- Reviewer for:
  - Annual Reviews in Control
  - ASME J. Biomechanical Engineering
  - Automatica
  - Biological Cybernetics
  - Chaos
  - IEEE Conference on Decision and Control
  - IEEE International Conference on Robotics and Automation
  - IEEE Transactions on Automatic Control
  - International Symposium on Nonlinear Theory and Its Applications
  - Mathematics of Control, Signals, and Systems
  - Robotics: Science and Systems;
  - Scientific Reports;
  - SIAM J. Control and Optimization;
  - Stochastic Models
- Professional Memberships:
  - American Mathematical Society
  - Institute of Electrical and Electronics Engineers
  - Society for Industrial and Applied Mathematics
  - SIAM Activity Groups on Dynamical Systems and on Control and Systems Theory