

# Todd D. Murphey

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## EDUCATION

**California Institute of Technology** Pasadena, CA

- Ph.D. in Control and Dynamical Systems, 2002
- Thesis: *Control of Multiple Model Systems*

**University of Arizona** Tucson, AZ

- B.S. in Mathematics, *summa cum laude*, 1997

## EMPLOYMENT

**Northwestern University** 2009-present  
*Professor* 2017 - present  
*Associate Professor* 2011-2017  
*Assistant Professor* 2009-2011

**University of Colorado at Boulder** 2004-2008  
*Assistant Professor*

**Aerospace Corporation** 2003-2004  
*Senior Technical Staff*

**Northwestern University** 2002-2003  
*Postdoctoral Scholar*

## AWARDS AND HONORS

- Defense Science Study Group (DSSG)—one of fifteen scientists/engineers nationwide selected to participate in the DARPA/IDA DSSG for the two year program in 2014-2015
- Charles Deering McCormick Professor of Teaching Excellence—one of three awarded across the university—in 2014
- Invited speaker on Massive Open Online Courses (MOOCs) in universities for National Academy of Engineering Frontiers of Engineering Education Symposium in 2013
- National Science Foundation CAREER award in 2006

PUBLICATIONS<sup>1</sup> AND SOFTWARE

## Journal Articles

- [43] T. Berrueta, A. Pervan, K. Fitzsimons, and T. Murphey, “Dynamical system segmentation for information measures in motion,” *IEEE Robotics and Automation Letters*, 2019.
- [42] K. Flaßkamp and T. D. Murphey, “Structure-preserving local optimal control of mechanical systems,” *Optimal Control, Applications and Methods*, 2019.
- [41] E. Tzorakoleftherakis and T. D. Murphey, “Iterative sequential action control for stable, model-based control of nonlinear systems,” *IEEE Transactions on Automatic Control*, 2019.
- [40] G. Mamakoukas, M. Maciver, and T. D. Murphey, “Feedback synthesis for underactuated systems using sequential second-order needle variations,” *International Journal of Robotics Research*, 2019.
- [39] I. Abraham and T. Murphey, “Decentralized ergodic control: Distribution-driven sensing and exploration for multi-agent systems,” *IEEE Robotics and Automation Letters*, vol. 3, no. 4, pp. 2987–2994, 2018.
- [38] A. Mavrommati, E. Tzorakoleftherakis, I. Abraham, and T. D. Murphey, “Real-time area coverage and target localization using receding-horizon ergodic exploration,” *IEEE Transactions on Robotics*, vol. 34, no. 1, pp. 62–80, 2018.
- [37] M. A. MacIver, L. Schmitz, U. Mugan, T. D. Murphey, and C. D. Mobley, “A massive increase in visual range preceded the origin of terrestrial vertebrates,” *Proceedings of the National Academy of Science (PNAS)*, vol. 114, no. 12, pp. E2375–E2384, 2017.
- [36] I. Abraham, A. Prabhakar, M. Hartmann, and T. Murphey, “Ergodic exploration using binary sensing for non-parametric shape estimation,” *IEEE Robotics and Automation Letters*, vol. 2, no. 2, pp. 827–834, 2017.
- [35] A. D. Wilson, J. A. Schultz, A. Ansari, and T. D. Murphey, “Dynamic task execution using active parameter identification with the Baxter research robot,” *IEEE Transactions on Automation Science and Engineering*, vol. 14, no. 1, pp. 391–397, 2017.
- [34] K. Flaßkamp, A. Ansari, and T. D. Murphey, “Hybrid control for tracking of invariant manifolds,” *Nonlinear Analysis: Hybrid Systems*, vol. 25, pp. 298–311, 2017.
- [33] J. Schultz, K. Flaßkamp, and T. D. Murphey, “Variational integrators for structure-preserving filtering,” *ASME Journal of Computational and Nonlinear Dynamics*, vol. 12, no. 2, pp. 021005:1–021005:10, 2016.
- [32] A. Broad, M. Derry, J. Schultz, T. Murphey, and B. Argall, “Trust adaptation leads to lower control effort in shared control of crane automation,” *IEEE Robotics and Automation Letters*, vol. 2, no. 1, pp. 239–246, 2016.
- [31] A. Ansari and T. D. Murphey, “Sequential Action Control: Closed-form optimal control for nonlinear and nonsmooth systems,” *IEEE Transactions on Robotics*, vol. 32, no. 5, pp. 1196–1214, 2016.
- [30] A. Farshchiansadegh, A. Melendez-Calderon, R. Ranganathan, T. D. Murphey, and F. Mussa-Ivaldi, “Sensory agreement guides energy optimization in human movements,” *PLOS Computational Biology*, vol. 12, no. 4, p. e1004861, 2016.
- [29] A. Mavrommati, J. Schultz, and T. D. Murphey, “Real-time mode scheduling using single-integration hybrid optimization for linear time-varying systems,” *IEEE Transactions on Automation Science and Engineering*, vol. 13, no. 3, pp. 1385–1398, 2016.

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<sup>1</sup>Reprints of many of these can be found at <http://nrx.northwestern.edu/people/todd-murphey>

- [28] E. Tzorakoleftherakis, T. D. Murphey, and R. A. Scheidt, "Augmenting sensorimotor control using goal-aware vibrotactile stimulation during reaching and manipulation behaviors," *Experimental Brain Research*, vol. 234, no. 8, pp. 2403–2414, 2016.
- [27] A. Ansari and T. D. Murphey, "Minimum sensitivity control for planning with parametric and hybrid uncertainty," *International Journal of Robotics Research*, vol. 35, no. 7, pp. 823–839, 2016.
- [26] E. Tzorakoleftherakis, A. Ansari, A. Wilson, J. Schultz, and T. D. Murphey, "Model-based reactive control for hybrid and high-dimensional robotic systems," *IEEE Robotics and Automation Letters*, vol. 1, no. 1, pp. 431–438, 2016.
- [25] T. Caldwell and T. D. Murphey, "Projection-based iterative mode scheduling for switched systems," *Nonlinear Analysis: Hybrid Systems*, vol. 21, pp. 59–83, 2016.
- [24] L. Miller, Y. Silverman, M. A. MacIver, and T. Murphey, "Ergodic exploration of distributed information," *IEEE Transactions on Robotics*, vol. 32, no. 1, pp. 36–52, 2016.
- [23] D. Pekarek and T. D. Murphey, "Discrete Lagrangian mechanics for nonsmooth nonseparable systems," *International Journal for Numerical Methods in Engineering*, vol. 105, pp. 440–463, 2016.
- [22] R. Abbott, A. Pedler, M. Sterling, J. Hides, T. D. Murphey, M. Hoggarth, and J. Elliott, "The geography of fatty infiltrates within the cervical multifidus and semispinalis cervicis in individuals with chronic whiplash-associated disorders," *Journal of Orthopaedic and Sports Physical Therapy*, vol. 45, no. 4, pp. 281–288, 2015.
- [21] E. Johnson, J. Schultz, and T. D. Murphey, "Linearizations of variational integrators for analysis and optimization," *IEEE Transactions on Automation Science and Engineering*, vol. 12, no. 1, pp. 140–152, 2015.
- [20] A. Wilson, J. Schultz, and T. D. Murphey, "Trajectory optimization for well-conditioned parameter estimation," *IEEE Transactions on Automation Science and Engineering*, vol. 12, no. 1, pp. 28–36, 2015.
- [19] A. Wilson, J. Schultz, and T. D. Murphey, "Trajectory synthesis for Fisher information maximization," *IEEE Transactions on Robotics*, vol. 30, no. 6, pp. 1358–1370, 2014.
- [18] B. Quist, V. Seghete, L. Huet, T. D. Murphey, and M. J. Z. Hartmann, "Modeling forces and moments at the base of a rat vibrissa during non contact whisking and whisking against an object," *Journal of Neuroscience*, vol. 34, pp. 9828–9844, July 2014.
- [17] V. Seghete and T. D. Murphey, "Uniqueness conditions for simultaneous impact in locomotion: existence, uniqueness, and design consequences," *IEEE Transactions on Automation Science and Engineering*, vol. 11, no. 1, pp. 154–168, 2014.
- [16] L. Miller and T. D. Murphey, "Simultaneous optimal estimation of mode transition times and parameters applied to simple traction models," *IEEE Transactions on Robotics*, vol. 29, no. 6, pp. 1496–1503, 2013.
- [15] Y. P. Leong and T. D. Murphey, "Feature localization using kinematics and impulsive hybrid optimization," *IEEE Transactions on Automation Science and Engineering*, vol. 10, no. 4, pp. 957 – 968, 2013.
- [14] T. Caldwell and T. D. Murphey, "Single integration optimization of linear time-varying switched systems," *IEEE Transactions on Automatic Control*, vol. 57, no. 6, pp. 1592–1597, 2012.
- [13] E. Johnson and T. D. Murphey, "Second-order switching time optimization for nonlinear time-varying dynamic systems," *IEEE Transactions on Automatic Control*, vol. 56, no. 8, pp. 1953–1957, 2011.

- [12] P. Martin, E. Johnson, T. D. Murphey, and M. Egerstedt, “Constructing and implementing motion programs for robotic marionettes,” *IEEE Transactions on Automatic Control*, vol. 56, no. 4, pp. 902–907, 2011.
- [11] T. Caldwell and T. D. Murphey, “Switching mode generation and optimal estimation with application to skid-steering,” *Automatica*, vol. 47, no. 1, pp. 50–64, 2011.
- [10] T. D. Murphey and J. Falcon, “Programming from the ground up in controls laboratories,” *International Journal of Engineering Education*, vol. 26, no. 5, pp. 1241–1248, 2010.
- [9] E. Jochum and T. D. Murphey, “A Robotic Pygmalion: Choreography for an automated marionette play,” *Puppetry International*, vol. 27, pp. 22–24, 2010.
- [8] E. Johnson and T. D. Murphey, “Scalable variational integrators for constrained mechanical systems in generalized coordinates,” *IEEE Transactions on Robotics*, vol. 25, no. 6, pp. 1249–1261, 2009.
- [7] B. Shucker, T. D. Murphey, and J. Bennett, “Convergence preserving switching for topology-dependent decentralized systems,” *IEEE Transactions on Robotics*, vol. 24, no. 6, pp. 1405–1415, 2008.
- [6] T. D. Murphey and K. M. Lynch, “Case studies in planar part feeding and assembly based on design of limit sets,” *International Journal of Robotics Research*, vol. 27, pp. 693–708, June 2008.
- [5] T. D. Murphey, “Teaching rigid body mechanics using student-created virtual environments,” *IEEE Transactions on Education*, vol. 51, no. 1, pp. 45–52, 2008.
- [4] T. D. Murphey, “On multiple model control for multiple contact systems,” *Automatica*, vol. 44, pp. 451–458, 2008.
- [3] T. D. Murphey, “Kinematic reductions for uncertain mechanical contact,” *Robotica*, vol. 25, pp. 751–764, Nov 2007.
- [2] T. D. Murphey and J. W. Burdick, “The power dissipation method and kinematic reducibility of multiple model robotic systems,” *IEEE Transactions on Robotics*, vol. 22, pp. 694–710, August 2006.
- [1] T. D. Murphey and J. W. Burdick, “Feedback control methods for distributed manipulation systems that involve mechanical contacts,” *International Journal of Robotics Research*, vol. 23, pp. 763–782, July 2004.

### Peer Reviewed Conference Papers

- [120] A. Broad, T. Murphey, and B. Argall, “Operation and imitation under safety-aware shared control,” in *Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2018.
- [119] I. Abraham, A. Prabhakar, and T. D. Murphey, “Active area coverage from equilibrium,” in *Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2018.
- [118] T. Fan, J. Schultz, and T. D. Murphey, “Efficient computation of higher-order variational integrators in robotic simulation and trajectory optimization,” in *Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2018.
- [117] A. Pervan and T. D. Murphey, “Low complexity control policy synthesis for cyber-free robot design,” in *Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2018.
- [116] G. Mamakoukas, M. MacIver, and T. D. Murphey, “Superlinear convergence using controls based on second-order needle variations,” in *IEEE Int. Conf. on Decision and Control (CDC)*, 2018.
- [115] I. Abraham, A. Mavrommati, and T. D. Murphey, “Data-driven measurement models for active localization in sparse environments,” in *Robotics: Science and Systems Proceedings*, 2018.

- [114] A. Kalinowska, K. Fitzsimons, J. Dewald, and T. D. Murphey, “Online user assessment for minimal intervention during task-based robotic assistance,” in *Robotics: Science and Systems Proceedings*, 2018.
- [113] A. Broad, I. Abraham, B. Argall, and T. D. Murphey, “Structured neural networks for model-based control,” in *Robotics: Science and Systems (RSS) Workshop on Learning and Inference in Robotics*, 2018.
- [112] A. Broad, T. D. Murphey, and B. Argall, “Demonstration and imitation of novel behaviors under safety aware control,” in *Robotics: Science and Systems (RSS) Workshop on Causal Imitation in Robotics*, 2018.
- [111] O. Ennasr, G. Mamakoukas, T. D. Murphey, and X. Tan, “Ergodic exploration for adaptive sampling of water columns using gliding robotic fish,” in *ASME Dynamic Systems and Control Conference (DSCC)*, 2018.
- [110] T. Fan, H. Weng, and T. D. Murphey, “Decentralized and recursive identification for cooperative manipulation of unknown rigid body with local measurements,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 2842–2849, 2017.
- [109] I. Abraham, G. de la Torre, and T. Murphey, “Model-based control using Koopman operators,” in *Robotics: Science and Systems Proceedings*, 2017.
- [108] G. Mamakoukas, M. MacIver, and T. Murphey, “Feedback synthesis for controllable underactuated systems using sequential second order actions,” in *Robotics: Science and Systems Proceedings*, 2017.
- [107] A. Broad, T. Murphey, and B. Argall, “Learning models for shared control of human-machine systems with unknown dynamics,” in *Robotics: Science and Systems Proceedings*, 2017.
- [106] M. Castano, A. Mavrommati, T. D. Murphey, and X. Tan, “Trajectory planning and tracking of robotic fish using ergodic exploration,” in *American Controls Conf. (ACC)*, pp. 5476 – 5481, 2017.
- [105] A. Prabhakar, A. Mavrommati, J. Schultz, and T. D. Murphey, “Autonomous visual rendering using physical motion,” in *Workshop on the Algorithmic Foundations of Robotics (WAFR)*, 2016.
- [104] J. Schultz and T. D. Murphey, “Low-infrastructure real-time embedded control via variational integrators,” *PAMM*, vol. 16, no. 1, pp. 949–952, 2016.
- [103] G. De La Torre and T. D. Murphey, “On the benefits of surrogate Lagrangians in optimal control and planning algorithms,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 7384–7391, 2016.
- [102] A. Mavrommati and T. D. Murphey, “Automatic synthesis of control alphabet policies,” in *IEEE Int. Conf. on Automation Science and Engineering (CASE)*, pp. 313 – 320, 2016.
- [101] T. Fan and T. D. Murphey, “Online feedback control for input-saturated robotic systems on Lie groups,” in *Robotics: Science and Systems Proceedings*, 2016.
- [100] G. Mamakoukas, M. MacIver, and T. D. Murphey, “Controlling simulated underactuated underwater vehicles with added mass and velocity drift using sequential action control,” in *American Controls Conf. (ACC)*, pp. 4500 – 4506, 2016.
- [99] G. De La Torre, K. Flaßkamp, A. Prabhakar, and T. D. Murphey, “Ergodic exploration with stochastic sensor dynamics,” in *American Controls Conf. (ACC)*, pp. 2971 – 2976, 2016.
- [98] K. Fitzsimons, E. Tzorakoleftherakis, and T. D. Murphey, “Optimal human-in-the-loop interfaces based on Maxwell’s demon,” in *American Controls Conf. (ACC)*, pp. 4397 – 4402, 2016.

- [97] T. Fan and T. D. Murphey, “Structured linearization of discrete mechanical systems on Lie groups: a synthesis of analysis and control,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 1092 – 1099, 2015.
- [96] A. Prabhakar, K. Flaßkamp, and T. D. Murphey, “Symplectic integration for optimal ergodic control,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 2594 – 2600, 2015.
- [95] E. Tzorakoleftherakis and T. D. Murphey, “Controllers as filters: Noise-driven swing-up control based on Maxwell’s demon,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 4368 – 4374, 2015.
- [94] A. Wilson, J. Schultz, A. Ansari, and T. D. Murphey, “Real-time trajectory synthesis for information maximization using Sequential Action Control and least-squares estimation,” in *IEEE Int. Conf. on Intelligent Robots and Systems (IROS)*, pp. 4935–4940, 2015.
- [93] T. Caldwell and T. D. Murphey, “Power network regulation benchmark for switched-mode optimal control,” in *Analysis and Design of Hybrid Systems (ADHS)*, pp. 280–285, 2015.
- [92] A. Ansari, K. Flaßkamp, and T. D. Murphey, “Sequential action control for tracking of free invariant manifolds,” in *Analysis and Design of Hybrid Systems (ADHS)*, pp. 335–342, 2015.
- [91] L. Miller and T. D. Murphey, “Optimal planning for target localization and coverage using range sensing,” in *IEEE Int. Conf. on Automation Science and Engineering (CASE)*, pp. 501–508, 2015.
- [90] A. Mavrommati, A. Ansari, and T. D. Murphey, “Optimal control-on-request: An application in real-time assistive balance control,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 5928 – 5934, 2015.
- [89] E. Tzorakoleftherakis, M. C. Bengtson, F. A. Mussa-Ivaldi, R. A. Scheidt, and T. D. Murphey, “Tactile proprioceptive input in robotic rehabilitation after stroke,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 6475 – 6481, 2015.
- [88] A. D. Wilson and T. D. Murphey, “Maximizing Fisher information in discrete-time mechanical systems using projection-based trajectory optimization,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 2403 – 2409, 2015.
- [87] A. Ansari and T. D. Murphey, “Control-on-request: Short-burst assistive control for long time horizon improvement,” in *American Controls Conf. (ACC)*, pp. 1173 – 1180, 2015.
- [86] A. Ansari and T. D. Murphey, “A variational derivation of LQR for piecewise time-varying systems,” in *American Controls Conf. (ACC)*, pp. 2260 – 2265, 2015.
- [85] K. Flaßkamp and T. D. Murphey, “Variational integrators in linear optimal control and filtering,” in *American Controls Conf. (ACC)*, pp. 5140 – 5145, 2015.
- [84] T. Murphey and B. Argall, “Towards software-enabled rehabilitation,” in *IROS Workshop on Workshop on Rehabilitation & Assistive Robotics*, 2014.
- [83] I. D. Neveln, L. M. Miller, M. A. MacIver, and T. Murphey, “Improving object tracking through distributed exploration of an information map,” in *IEEE Int. Conf. on Intelligent Robots and Systems (IROS)*, pp. 3441 – 3447, 2014.
- [82] A. Mavrommati and T. D. Murphey, “Single-integration mode scheduling for linear time-varying switched systems,” in *American Controls Conf. (ACC)*, pp. 430 – 436, 2014.
- [81] E. Tzorakoleftherakis, F. Mussa-Ivaldi, R. Scheidt, and T. D. Murphey, “Effects of optimal tactile feedback in balancing tasks: a pilot study,” in *American Controls Conf. (ACC)*, pp. 778 – 783, 2014.

- [80] V. Seghete and T. D. Murphey, “Continuous-time optimal control of impacting mechanical systems via a projected Hamilton’s principle,” in *American Controls Conf. (ACC)*, pp. 2438 – 2444, 2014.
- [79] J. Schultz and T. D. Murphey, “Extending filter performance through structured integration,” in *American Controls Conf. (ACC)*, pp. 261 – 270, 2014.
- [78] A. Wilson and T. D. Murphey, “Local E-optimality conditions for trajectory design to estimate parameters in nonlinear systems,” in *American Controls Conf. (ACC)*, pp. 443 – 450, 2014.
- [77] E. Jochum, J. Schultz, and T. Murphey, “Engineering autonomous theatre: The impact of culture on mobile robots and automated systems,” in *AAMAS Workshop on Culture Aware Robotics*, 2014.
- [76] E. Jochum, G. Borggreen, and T. Murphey, “INTERACT: Applying theory and methods from the visual and performing arts to robots,” in *HRI-Workshop on Culture Aware Robotics*, 2014.
- [75] K. Flaßkamp, T. D. Murphey, and S. Ober-Blöbaum, “Optimization for discretized switched systems,” *PAMM*, vol. 13, no. 1, pp. 401–402, 2013.
- [74] T. Caldwell and T. D. Murphey, “Projection-based optimal mode scheduling,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 5307 – 5314, 2013.
- [73] L. Miller and T. D. Murphey, “Trajectory optimization for continuous ergodic exploration on the motion group  $SE(2)$ ,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 4517 – 4522, 2013.
- [72] D. Pekarek and T. D. Murphey, “A projected Lagrange-d’Alembert principle for forced nonsmooth mechanics and optimal control,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 7777 – 7784, 2013.
- [71] A. Ansari and T. Murphey, “Minimal sensitivity control for hybrid environments,” in *IEEE Int. Conf. on Intelligent Robots and Systems (IROS)*, pp. 3023 – 3028, 2013.
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- [68] K. Flaßkamp, T. D. Murphey, and S. Ober-Blöbaum, “Discretized switching time optimization problems,” in *European Control Conference (ECC)*, pp. 3179–3184, 2013.
- [67] Y. P. Leong and T. D. Murphey, “Second-order switching time and magnitude optimization for impulsive hybrid systems,” in *American Controls Conf. (ACC)*, pp. 6213–6218, 2013.
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- [64] A. Ansari and T. D. Murphey, “Minimal parametric sensitivity trajectories for nonlinear systems,” in *American Controls Conf. (ACC)*, pp. 5011–5016, 2013.
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- [60] K. Flaßkamp, T. D. Murphey, and S. Ober-Blöbaum, “Switching time optimization in discretized hybrid dynamical systems,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 707–712, 2012.
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- [57] M. Travers, T. D. Murphey, and L. Y. Pao, “Linear time-varying impulse optimization for data association,” in *American Controls Conf. (ACC)*, pp. 1047–1052, 2012.
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- [55] T. D. Murphey and B. Argall, “Making robotic marionettes perform,” in *ICRA Workshop on Robotics and Performance Arts: Reciprocal Influences*, 2012.
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- [25] T. D. Murphey and M. Horowitz, "Adaptive cooperative manipulation with intermittent contact," in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 1483–1488, 2008.
- [24] M. Egerstedt, T. D. Murphey, and J. Ludwig, *Hybrid Systems: Computation and Control*, ch. Motion Programs for Puppet Choreography and Control, pp. 190–202. Lecture Notes in Computer Science, Springer-Verlag, 2007. Eds. A. Bemporad, A. Bicchi, and G. C. Buttazzo.

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- [22] E. Johnson and T. D. Murphey, “Dynamic modeling and motion planning for marionettes: Rigid bodies articulated by massless strings,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 330–335, 2007.
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- [19] T. D. Murphey and J. Falcon, “Programming from the ground up in controls laboratories using graphical programming,” in *Proceedings of the IFAC Advances in Control Education (ACE)*, p. 6 pages, 2006.
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- [11] T. D. Murphey, D. Choi, J. Bernheisel, and K. M. Lynch, “Experiments in the use of stable limits sets for parts handling,” in *Proc. Int. Conf. MEMS, NANO, and Smart Systems (ICMENS)*, pp. 218–224, 2004.
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- [8] T. D. Murphey and J. W. Burdick, “Smooth feedback control algorithms for fully actuated distributed manipulators,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 3619–3623, 2003.
- [7] T. D. Murphey and J. W. Burdick, “Nonsmooth controllability theory and an example,” in *IEEE Int. Conf. on Decision and Control (CDC)*, pp. 370–376, 2002.
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- [5] T. D. Murphey and J. W. Burdick, “A local controllability test for nonlinear multiple model systems,” in *American Controls Conf. (ACC)*, pp. 4657–4661, 2002.
- [4] T. D. Murphey and J. W. Burdick, “Global stability for distributed systems with changing contact states,” in *IEEE Int. Conf. on Intelligent Robots and Systems (IROS)*, pp. 214–219, 2001.
- [3] T. D. Murphey and J. W. Burdick, “A controllability test and motion planning primitives for overconstrained vehicles,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 2716–2722, 2001.
- [2] T. D. Murphey and J. W. Burdick, “On the stability and design of distributed systems,” in *IEEE Int. Conf. on Robotics and Automation (ICRA)*, pp. 2686–2691, 2001.
- [1] T. D. Murphey and J. W. Burdick, “Issues in controllability and motion planning for overconstrained wheeled vehicles,” in *Proc. Int. Conf. Math. Theory of Networks and Systems (MTNS)*, p. 8 pages, 2000.

### Editor Reviewed Book Chapters

- [7] A. Pervan and T. D. Murphey, *Robotic Systems and Autonomous Platforms: Advances in Materials and Manufacturing*, ch. Algorithmic Materials: Embedding Computation within Material Properties for Autonomy. Elsevier, In Press. Eds. M. Strano and S. Walsh.
- [6] A. Mavrommati, A. Ansari, and T. D. Murphey, *Trends in Control and Decision-Making for Human-Robot Collaboration Systems*, ch. Assistive Optimal Control-on-Request with Application in Standing Balance Therapy and Reinforcement, pp. 131–156. Springer, 2017. Eds. Y. Wang and F. Zhang.
- [5] J. Schultz, E. Johnson, and T. D. Murphey, *Differential-Geometric Methods in Computational Multibody System Dynamics*, ch. Trajectory Optimization in Discrete Mechanics. CISM, 2015. Eds. Z. Terze and A. Mueller.
- [4] E. Jochum, J. Schultz, E. Johnson, and T. D. Murphey, *Art and Control*, ch. Robotic Puppets and the Engineering of Autonomous Theater. Springer-Verlag, 2013. Eds. A. LaViers and M. Egerstedt.
- [3] E. Jochum and T. D. Murphey, *New Scholarship on Puppetry and Performing Objects*, ch. Programming Play: Puppets, Robots, and Engineering. Springer-Verlag, 2012. Eds. D. Posner, J. Bell, and C. Orenstein.
- [2] T. D. Murphey, *Multi-point Interaction with Real and Virtual Objects*, ch. On Observing Contact States in Overconstrained Manipulation, pp. 151–164. Springer-Verlag, 2005. Eds. F. Barbagli, D. Prattichizzo, and K. Salisbury.
- [1] K. M. Lynch and T. D. Murphey, *Control Problems in Robotics and Automation*, ch. Control of Nonprehensile Manipulation, pp. 39–57. Springer-Verlag, 2003. Eds. A. Bicchi and H. Christensen.

### Unrefereed Papers, Abstracts, and Posters

- [12] T. D. Murphey, “Sequential action control for nonlinear and hybrid systems,” in *Proceedings of the Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM)*, 2015.
- [11] J. Schultz and T. Murphey, “Real-time trajectory generation for a planar crane using discrete mechanics,” in *IROS Workshop on Real-Time Systems*, 2014.
- [10] R. Abbott, A. Pedler, M. Sterling, J. Hides, T. Murphey, M. Hoggarth, and J. Elliott, “The distribution of muscle fat infiltration within the deep extensor muscles in

- whiplash-associated disorders,” in *American Physical Therapy Association Combined Sessions Meeting: Orthopaedics*, 2015.
- [9] B. Argall and T. Murphey, “Computable trust in human instruction,” in *AAAI Symposium on AI for Human-Robot Interaction*, 2014.
- [8] T. D. Murphey, D. Pekarek, and V. Seghete, “Variational methods for contact mechanics,” in *Robotics Science and Systems Workshop: Toward High-Performance Computing Support for Simulation and Planning of Robot Contact Tasks*, 2011.
- [7] B. Quist, V. Seghete, T. D. Murphey, and M. Hartmann, “Modeling forces and moments at the vibrissal base during natural motion and collisions,” in *The Royal Society*, 2011.
- [6] G. S. Chirikjian, H. M. Choset, M. A. Morales, and T. D. Murphey, “Editorial: Special issue on eighth international workshop on the algorithmic foundations of robotics,” *International Journal of Robotics Research*, 2010.
- [5] T. D. Murphey, “Topology-based variational integration of degenerate interconnected mechanical systems,” in *European Conference on Computational Mechanics (ECCM)*, 2010.
- [4] T. D. Murphey, “Poster: Hybrid sensing with physical sensors,” in *Int. Conf. on Chaos and Nonlinear Dynamics*, 2010.
- [3] K. L. Snyder and T. D. Murphey, “Abstract: Mathematical tools for tracking uncertainty through gait,” in *Dynamic Walking: Principles and Concepts of Legged Locomotion*, 2009. 1 page.
- [2] E. Johnson and T. D. Murphey, “The automated marionette project,” in *AAAI Robotics and Creativity Workshop*, 2008.
- [1] T. D. Murphey and M. E. Egerstedt, “Choreography for marionettes: Imitation, planning, and control,” in *IEEE Int. Conf. on Intelligent Robots and Systems Workshop on Art and Robotics*, 2007. 6 pages.

## Books

- [1] G. S. Chirikjian, H. M. Choset, M. A. Morales, and T. D. Murphey, eds., *Algorithmic Foundation of Robotics VIII*, vol. 57 of *Springer Tracts in Advanced Robotics*. Springer-Verlag, 2009.

## Publicly Available Software

- [2] A. Ansari and T. D. Murphey. The SAC library for nonlinear control can be used for approximate optimal control of general nonlinear and nonsmooth systems. It is available at <https://github.com/alexansari101/saclib>.
- [1] E. Johnson, J. Schultz, and T.D. Murphey. The `trep` environment is a computation package for simulation and control of constrained mechanical systems. The `trep` environment is available at <https://github.com/MurpheyLab/trep>.

## MEDIA AND ARTS

- Exhibit: laboratory robots (including robotic marionettes, human-machine interfaces, drawing robots, and rehabilitation robotics) featured in National Robotics Week exhibit at the Chicago Museum of Science and Industry (2013-2018)
- Work featured in National Science Foundation *Science Nation* online magazine (2017).
- Panelist for Volkenburg Puppetry Symposium *The Uncanny Valley: Real Fakeness and Fake Realness*.
- Op-Ed: “Creating Content for Many to Access a Few” in *Pacific Standard Magazine*, March, 2014.

- Talk: “Context and Liveness” at panel *The Uncanny Valley Revisited: A Tribute to Masuhiro Mori* at IROS (2013)

## FUNDING

- Todd D. Murphey (PI, 50%), Brenna Argall (Co-PI, 50%). National Science Foundation–Cyber-Physical Systems: *CPS: Medium: Information based Control of Cyber-Physical Systems operating in uncertain environments*. \$896,000.
- Todd D. Murphey (PI) and Xiabo Tan. National Science Foundation–Information and Intelligent Systems: *RI: Small: Collaborative Research: Information-driven Autonomous Exploration in Uncertain Underwater Environments*. \$500,000.
- Todd D. Murphey (PI). National Science Foundation–Civil and Mechanical Systems: *Stability and Optimality Properties of Sequential Action Control for Nonlinear and Hybrid Systems*. \$375,000.
- Todd D. Murphey (PI). National Science Foundation–National Robotics Initiative: *Task-Based Assistance for Software-Enabled Biomedical Devices*. \$430,000.
- Todd D. Murphey (PI), Eva Kanso, Yasamin Mostofi, Evangelos Theodorou. Army Research Office: *Study Proposal: Transforming Terrestrial Agility At All Scales*. \$60,000.
- Mitra Hartmann (PI), Todd Murphey, John Rudnicki, Sara Solla. National Institutes of Health: *Coding properties of Vibrissal-Responsive Trigeminal Ganglion Neurons*. \$1,800,000.
- Todd D. Murphey. Army Research Office: *Ergodic Control for Optimal Information Acquisition*. \$360,000.
- Todd D. Murphey (PI, 50%), J. Edward Colgate (Co-PI, 50%). National Science Foundation–National Robotics Initiative: *Autonomous Synthesis of Haptic Languages*. \$585,000.
- Malcolm A. MacIver (PI, 40%), Michael Peshkin (Co-PI, 30%), Todd D. Murphey (Co-PI, 30%). Office of Naval Research: *A Bio-Inspired Underwater Robot for Station Keeping with Omnidirectional Disturbances*. \$1,000,000.
- Todd D. Murphey (PI, 35%), Brenna Argall (Co-PI, 35%), and Magnus Egerstedt (Co-PI, 30%). National Science Foundation–Cyber-Physical Systems: *Collaborative Research: Mutually stabilized correction in physical demonstration*. \$1,000,000.
- Todd D. Murphey (PI, 50%) and Melvin Leok (Co-PI, 50%). National Science Foundation–Civil and Mechanical Systems: *Ergodic Trajectories in Discrete Mechanics*. \$430,000.
- Todd D. Murphey. National Institute of Health–R24: *Exoskeleton Evaluation for Hemiplegia Therapy*. \$50,000.
- Todd D. Murphey. National Science Foundation–Civil and Mechanical Systems: *Physical Design and Feedback Control of Hybrid Mechanical Systems*. \$350,000.
- Kevin Lynch (PI), Brenna Argall, J. Edward Colgate, Todd D. Murphey, and Ying Wu (Co-PIs). National Science Foundation: *MRI: Equipment Development: Bimanual Robotic Manipulation and Sensory Workspace*. \$400,000.
- Todd D. Murphey (PI, 50%) and Kevin Lynch (Co-PI, 50%). National Science Foundation–Robust Intelligence: *Hierarchical Planning, Estimation, and Control for Hybrid Mechanical Systems*. \$450,000.
- W. Murray (PI, 50%), T. D. Murphey (Co-PI, 50%), National Institutes of Health: *Prosthesis Control by Forward Simulation of the Intact Biomedical System*. (Northwestern portion) \$550,000.

- Todd D. Murphey (Consultant to Kinea, 10%) DARPA: *SBIR Phase I: Tactile Detection Robotic Hand System*. Murphey's portion is \$10,000
- Todd D. Murphey (PI, 50%) and Magnus Egerstedt (Co-PI, 50%). National Science Foundation–CreativeIT: *Collaborative Research: Major: Puppet Choreography and Automated Marionettes*. \$800,000.
- Magnus Egerstedt (Co-PI, 50%) and Todd D. Murphey (PI, 50%). National Science Foundation–Software for Real-World Systems: *Collaborative Proposal: Abstraction-Based Motion Programs for Complex, Interconnected Systems*. \$450,000.
- Lucy Y. Pao (PI, 50%) and Todd D. Murphey (Co-PI, 50%). Air Force Research Laboratory: *Data Association and Sensor Management Algorithms for Tracking Applications*. \$250,000.
- Todd D. Murphey. National Science Foundation–Advanced Learning Technology: *Assessment of Controls Laboratory*. \$24,591.
- Todd D. Murphey. National Science Foundation–Civil and Mechanical Systems: *CAREER: Planning and Control for Overconstrained Mechanisms*. \$400,000.

## TEACHING

### Teaching Highlights

- Northwestern University Cole-Higgins Award for Excellence in Teaching (2015)
- Northwestern University Charles Deering McCormick Professor of Teaching Excellence (2014)
- Northwestern University Cole-Higgins Award for Excellence in Advising (2013)
- Participant in National Academy of Engineering Frontiers of Engineering Education Symposium (2009)
- Searle Fellow at Northwestern University (2009-2010)
- Bruce Holland Excellence in Teaching award (2007) (ECE Department at CU Boulder)

### Coursera

2013-2014, [www.coursera.org](http://www.coursera.org)

- Created and taught course: *Everything Is The Same: Modeling Engineered Systems*; available at <http://www.coursera.org/course/modelsystems>.

### International Centre for Mechanical Sciences (CISM)

2013, Udine, Italy

- Lecturer for *Differential-Geometric Methods in Computational Multibody Systems*. (My portion of the lectures focused on engineering applications of structured integration and optimal control in the context of structured integration.)

### Northwestern University

2009-present, Evanston, IL

- Created and taught course: *Theory of Machines: Dynamics ME 314* (2009-present)
- Created and taught course: *Active Learning in Robotics, EA-3* (2018-present)
- Taught course: *Systems Dynamics, EA-3* (2009-present)
- Created and taught course: *Introduction to Optimal Control, ME 454* (2009-2017)
- Created and taught course: *Stochastic Systems in Robotics* (Spring, 2011)

### University of Colorado

2004-2008, Boulder, CO

- Created and taught course: *Engineering Freshman Honors Colloquium: Everything and More—A History of Limits and the Development of Modern Calculus* (Spring 2008)
- Created and taught course: *Engineering Freshman Projects: Algorithms in Robotics, GEEN 1400* (Fall 2007, 2008)
- Created and taught course: *Introduction to Geometric Mechanics and Control ECEN 4028/5028* (Spring 2006)
- Created and taught course: *Robot Dynamics and Motion Planning ECEN 4028/5028* (Spring 2006)
- Taught course: *Control Systems Analysis ECEN 4138* (Fall 2005, 2006)
- Created and taught laboratory: *Control Systems Lab ECEN 4638* (Fall 2005, 2006, 2007, 2008)
- Created and taught course: *Robot Control ECEN 5438* (Spring 2005, 2007)

## PROFESSIONAL ACTIVITIES

### Service Highlights

- Member: National Academies / National Research Council Committee on Counter-Unmanned Aircraft System (CUAS) Capability for Battalion-and-Below Operations (2016-2018)
- Presented at the Coalition for the National Science Foundation (CNSF) Capitol Hill Exhibition (2017)
- Senior Editor for *IEEE Transactions on Robotics* (2014-present)
- Member: Northwestern University Task Force on the Undergraduate Academic Experience (2015)

### University Service

- Chair: Northwestern University Faculty Distance Learning Workgroup (2015 - present)
- Director and Co-Founder of Master of Science in Robotics Program (2013-present)
- Member: Northwestern University Segal Design Institute Research Council
- Member: Feinberg School of Medicine DPT/PhD T32 Steering Committee
- Participant in Kellogg School of Management Executive Education 2013 Program *Management Skills for Innovative University Leaders*.

### External Service

- Associate Editor for
  - *IEEE Transactions on Automation Science and Engineering* (2010-2014)
  - *IEEE Transactions on Robotics* (2008-2012)
  - *Robotica* (2007-2011)
- Conference Organization
  - Local Arrangements Chair for the 2014 *IEEE International Conference on Intelligent Robots and Systems (IROS)*
  - Publication Chair for the 2010 *IEEE International Conference on Automation Science and Engineering (CASE)*
  - Co-Organizer (with Greg Chirikjian, Howie Choset, and Marco Morales) of 2008 *Workshop on the Algorithmic Foundations of Robotics (WAFR)*
- Workshop Organization
  - Member of advisory committee for 2017 *Midwest Workshop on Controls and Game Theory*

- Co-Organizer (with Ken Goldberg, Vijay Kumar, and Frank van der Stappen) of 2009 RSS *Workshop on Algorithmic Automation*
- Co-Chair (with Ken Goldberg, Jean-Paul Laumond, and Vijay Kumar) of CASE 2008 workshop: *Workshop on Algorithmic Automation*
- Co-Organizer (with Vijay Kumar) of ICRA 2008 workshop: *Contact Models for Manipulation and Locomotion*
- Co-Organizer (with Francisco Valero-Cuevas and Yoky Matsuoka) of ICRA 2008 workshop: *Is human-like dextrous manipulation within our robotic grasp?*
- Participant in the National Science Foundation and Computing Community Consortium (CCC) *Workshop on Robotics in Manufacturing and Automation*
- Conference Program committees
  - 2017 *Robotics: Science and Systems*: Area Chair
  - 2016 *Robotics: Science and Systems*: Area Chair
  - 2016 *Workshop on the Algorithmic Foundations of Robotics*
  - 2015 *IFAC Conference on Analysis and Design of Hybrid Systems*
  - 2012 *Workshop on the Algorithmic Foundations of Robotics*
  - 2009 *Robotics: Science and Systems*
  - 2008 *Hybrid Systems: Computation and Control*
  - 2008 *Robotics: Science and Systems*
  - 2008 *IEEE International Conference on Robotics and Automation*
  - 2008 *IEEE Conference on Automation Science and Engineering*
  - 2007 *IEEE/RSJ International Conference on Intelligent Robots and Systems*
  - 2007 *International Conference on Advanced Robotics*
  - 2007 *International Conference on Networked Robots*
  - 2007 *IEEE International Conference on Robotics and Automation*
  - 2006 *IEEE/RSJ International Conference on Intelligent Robots and Systems*
  - 2006 *IEEE International Conference on Robotics and Automation*
  - 2005 *Robotics: Science and Systems*
  - 2005 *IEEE/RSJ International Conference on Intelligent Robots and Systems*
  - 2001 *IEEE/RSJ International Conference on Intelligent Robots and Systems*
- Other Conference Committees
  - ICRA Best Student Paper 2012 (Chair)
  - CASE Best Paper 2010
  - ICRA Best Student Paper 2008
- National Science Foundation Panelist for programs ranging from control, education, robotics, cyberphysical systems, and others 2006-2017
- Member, IEEE, ASME, and AAAS

## STUDENTS AND POSTDOCS ADVISED

- Postdocs
  - Dr. Gerardo de la Torre (ME at Northwestern University), now at Northrop Grumman
  - Dr. Kathrin Flaßkamp (ME at Northwestern University), now a Postdoctoral Researcher at the University of Bremen



- Dr. David Pekarek (ME at Northwestern University), now a senior scientist at Data Tactics
- Dr. Benjamin Tovar (ME at Northwestern University), now a Research Software Engineer at Notre Dame
- Ph.D. Students
  - Brian Shucker (CS at University of Colorado), 2006 Ph.D. thesis: *Control of Distributed Robotic Macrosensors*, was at MIT Lincoln Laboratories, now at TALOS robotics.
  - Matt Travers (ME at Northwestern University), 2011 Ph.D. thesis: *Impulse Smoothing for Data Association*, now a Systems Scientist at Carnegie Mellon University.
  - Elliot Johnson (ME at Northwestern University), 2012 Ph.D. thesis: *Trajectory Optimization and Regulation for Constrained Discrete Mechanical Systems*, now at the Southwester Research Institute.
  - Elizabeth Jochum (Performance Studies at the University of Colorado), 2013 Ph.D. thesis: *Deux Ex Machina: Towards an Aesthetics of Autonomous and Semi-Autonomous Machines*, now an Assistant Professor at Aalborg University.
  - Tim Caldwell (ME at Northwestern University), 2013 Ph.D. thesis: *Iterative Methods in Switched System Optimal Control*, previously a postdoc at the University of Colorado at Boulder and now at Zoox (a driverless car startup company).
  - Vlad Seghete (ME at Northwestern University), 2014 Ph.D. thesis: *Numerical Methods for Simulation and Control of Impacting Mechanical Systems*. Now at DataScope Analytics.
  - Jarvis Schultz (ME at Northwestern University), 2014 Ph.D. thesis: *Discrete Mechanics Computation for Real-Time Embedded Control*, now at Northwestern University.
  - Andrew Wilson (ME at Northwestern University) 2015 Ph.D. thesis: *Information-based Trajectory Optimization for Active Estimation in Mechanical Systems*, now at Intuitive Surgical.
  - Alex Ansari (ME at Northwestern University), 2015 Ph.D. thesis: *Sequential Action Control: Closed-Form Optimal Feedback for Nonlinear and Hybrid Systems*. Postdoc at Carnegie Mellon University 2015-2017, now at Uber.
  - Lauren Miller (ME at Northwestern University), 2015 Ph.D. thesis: *Optimal Ergodic Control for Active Search and Information Acquisition*. Postdoc at UC Berkeley 2015-2016. Now at HERE (a driverless car software company).
  - Anastasia Mavrommati (ME at Northwestern University), 2017 Ph.D. thesis: *Real-Time Algorithms for Symbol-Based Automation*. Now at Schlumberger-Doll Research.
  - Emmanouil Tzorakoleftherakis (ME at Northwestern University), 2017 Ph.D. thesis: *Stable Control Synthesis for Human-in-the-Loop Systems*. Now at Mathworks.
  - Rebecca Abbott (ME/Physical Therapy at Northwestern University, co-advised with Prof. James Elliot.)

- Ahalya Prabhakar (ME at Northwestern University)
- Kathleen Fitzsimons (ME at Northwestern University)
- Giorgos Mamakoukas (ME at Northwestern University)
- Taosha Fan (ME at Northwestern University)
- Ian Abraham (ME at Northwestern University)
- Aleksandra (Ola) Kalinowska (ME at Northwestern University)
- Ana Pervan (ME at Northwestern University)
- Thomas Berrueta (ME at Northwestern University)
- Undergraduate and MS Students
  - Kirk Nichols (ECE at University of Colorado), now a graduate student at Stanford
  - Corrina Gibson (Aerospace at University of Colorado), now at the Jet Propulsion Laboratory
  - Matanya Horowitz (ECE at University of Colorado), now a graduate student at Caltech
  - Yoke Peng Leong (ME at Northwestern University), now a graduate student at Caltech
  - Katy Powers (ME at Northwestern University), now a graduate student at the University of Pennsylvania
  - Henry Hung (ME at Northwestern University)
  - Camaria Lehman (BME at Northwestern University)
  - Elliot Hevel (ME at Northwestern University)
  - Scott Beck (ME at Northwestern University)
  - Vismaya Walawalker (ME at Northwestern University)
  - Samuel Donis (ME at Northwestern University)
- Visiting Students
  - Amy LaViers (Georgia Institute of Technology, USA)
  - Rowland O'Flaherty (Georgia Institute of Technology, USA)
  - Kathrin Flaskkamp (Univ. of Paderborn, Germany)
  - Peter Kingston (Georgia Institute of Technology, USA)

## EXTERNAL ACTIVITIES

- Consultant for HDT for SOCOM TALOS exoskeleton project (2016-2017)
- Member of Nousot Scientific Advisory Board (2017-)