

Francesco Bullo

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Current Academic Employment

Associate Professor and Vice Chair (since Jul 2006), Mechanical Engineering
Affiliate, Department of Electrical and Computer Engineering
Affiliate, Center for Control, Dynamical Systems and Computation
Affiliate, Institute for Collaborative Biotechnologies
University of California at Santa Barbara

Summer 2004 – present

Previous Academic Employment

Research Assistant Professor, Coordinated Science Laboratory
Assistant Professor, Department of General Engineering
Affiliate, Department of Electrical and Computer Engineering
Affiliate, Department of Aerospace Engineering
University of Illinois at Urbana-Champaign

Fall 1998 – Summer 2004

Education

Ph.D., Control and Dynamical Systems, California Institute of Technology, Jun 1999
Laurea (M.S. equivalent), Electrical and Computer Engineering, University of Padova, Italy, Jun 1994

Research Interests

Control and coordination for robotic networks, distributed algorithmic control, motion planning for autonomous vehicles, and geometric control of mechanical systems. Applications include: (i) coordinated and adaptive networks of vehicles, embedded sensors and actuators, (ii) autonomous, reliable, and agile robots.

Research Awards and Honors

Plenary Speaker:

9th Workshop on Hybrid Systems: Computation and Control (HSCC), Santa Barbara, Mar 2006
25th Benelux Meeting on Systems and Control, The Netherlands, Mar 2006
Workshop Networked Embedded Sensing and Control, South Bend, Oct 2005
2nd IFAC Workshop Lagrangian & Hamiltonian Methods for Control, Spain, Apr 2003

SemiPlenary Speaker:

16th Symposium on Mathematical Theory of Networks and Systems (MTNS), Belgium, Jul 2004
Best Student Paper Award Winner (as advisor): CDC 2002, ACC 2006
Best Student Paper Award Finalist (as advisor): ACC 2005, CDC 2005, CDC 2007
Best Paper Award Finalist: ICRA 2002
IEEE Senior Member, 2003
Xerox Foundation Award for Faculty Research, UIUC College of Engineering, 2003
Young Investigator Award, Office of Naval Research, 2003
List of Teachers Rated Excellent by their Students, UIUC, Spring 2001
Gamma Epsilon Excellence in Teaching Award, General Engineering Department, UIUC, Spring 2001
Institute Fellowship, California Institute of Technology, Sep 1995 - Aug 1996
Laurea, Summa Cum Laude, University of Padova, Italy, 1994
Fellowship for Education Abroad Program, University of California at San Diego, 1992-1993

Teaching Awards and Activities

Invited Lecturer, Summer School on Modelling and Control of Complex Dynam. Systems, Bertinoro, Italy, Jul 2005
Invited Lecturer, Trimester in Control. Geometry and Engineering, Barcelona, Spain, Feb 2005
Outstanding Advisor Award, UIUC College of Engineering, Spring 2004

Invited Lecturer, Summer School, Dutch Institute for Systems and Control, Zeist, Netherlands, Jul 2002
List of Teachers Rated Excellent by their Students, UIUC, Spring 2001
Gamma Epsilon Excellence in Teaching Award, General Engineering Department, UIUC, Spring 2001
UIUC Aerial Robotics Club, Advisor, Fall 2000-Spring 2004

Courses taught, courses developed, or course outline revisions for:

UCSB Mechanical Engineering 225 "Cooperative control and robotic networks" (Fall 07)
UCSB Mechanical Engineering 225 "Geometric Control of Mechanical Systems" (Winter 06)
UCSB Mechanical Engineering 170A "Introduction to Robotics" (Spring 05,06)
UCSB Mechanical Engineering 155A "Control Systems Design" (Fall 04,05,06,07)
UIUC General Engineering 222 "Analysis of Dynamic Systems" (Spring 00,01, Fall 99,00)
UIUC General Engineering 330 "Introduction to Mechatronics" (Spring 02,03,04)
UIUC General Engineering 389 "Robot Dynamics and Control" (Fall 98)
UIUC General Engineering 489 "Robot Control Theory" (Spring 99, Fall 01,02)

Current Graduate Students and Postdoc

- (i) Stephen L. Smith (Ph.D. student, ME UCSB)
- (ii) Karl J. Obermeyer (Ph.D. student, ME UCSB)
- (iii) Shaunak D. Bopardikar (Ph.D. student, ME UCSB, co-advised with Prof. J. Hespanha)
- (iv) Joey Durham (Ph.D. student, ME UCSB)
- (v) Sandra Dandach (Ph.D. student, ME UCSB)
- (vi) Fabio Pasqualetti (Ph.D. student, ME UCSB, co-advised with Prof. A. Bicchi)
- (vii) Giulia Pavon (Ph.D. student, ME UCSB and ECE University of Padova)
- (viii) Nathan Owen (Ph.D. student, ME UCSB)
- (ix) Vaibhav Srivastava (Ph.D. student, ME UCSB)
- (x) Anahita Tabatabaei (Ph.D. student, ME UCSB)
- (xi) Kurt Plarre (PostDoc, CCDC and ICB)
- (xii) Ruggero Carli (PostDoc, CCDC)

Former PhD Students and Current Employment

- (i) Gregory W. Toussaint (Ph.D., co-advised, ECE UIUC, Jun 2000), now Deputy Department Head and Assistant Professor at the US Air Force Academy, Colorado
- (ii) W. Todd Cerven (Ph.D., co-advised, AAE UIUC, Jun 2003), now Senior Member of Technical Staff at The Aerospace Corporation, Chantille, Virginia
- (iii) Giuseppe Notarstefano (Ph.D., co-advised, ECE, University of Padova, Apr 2007), now Assistant Professor at the University of Lecce, Italy
- (iv) Anurag Ganguli (Ph.D., ECE UIUC, April 2007), now Senior Research and Development Engineer at UtopiaCompression Corporation, Los Angeles, California
- (v) Ketan Savla (Ph.D., ECE UCSB, Sep 2007), now Postdoc, MIT
- (vi) Sara Susca (Ph.D., ECE UCSB, Dec 2007), now Senior Engineer, Honeywell
- (vii) Nikolaj Nordkvist (Ph.D., co-advised, Math, Technical University of Denmark, Dec 2007), now Postdoc, University of Hawaii at Manoa

Former PostDoc Advisees and Current Employment

- (i) Jorge Cortés (Ph.D., Math, Universidad Carlos III, Spain, Sep 2001). Visiting PhD Student ('01) and PostDoc, CSL UIUC, Sep '02-'04, now Assistant Professor at University of California at Santa Cruz
- (ii) Sonia Martínez (Ph.D., Math, Universidad Carlos III, Spain, Feb 2002). Visiting PhD Student ('01) and PostDoc, UCSB, Dec '03-'05, now Assistant Professor at University of California at San Diego

Former M.S. Students and Current Employment

- (i) Peter K. Sochacki (M.S., ECE UIUC, Jan 2000), now at Anderson Engineering
- (ii) Arvind Hosagrahara, (M.S., GE UIUC, Jun 2001), now at MathWorks
- (iii) Ross Gadiant (M.S., GE UIUC, Jun 2001), now at Boeing
- (iv) Timur Karatas (M.S., GE UIUC, Jun 2001)
- (v) Craig Robinson (M.S., GE UIUC, Dec 2003), now at UIUC

- (vi) Mark Disch (M.S., ECE UIUC, Jun 2004), now at GE Energy
- (vii) Sulema Aranda (M.S., ECE UIUC, Aug 2004), now at Lockheed Martin
- (viii) Fabio Pasqualetti (Laurea, Università di Pisa, Jun 2007)
- (ix) Chunkai Gao (M.S., ME UCSB, Sep 2007)

Visiting Graduate Students and Research Fellow (1 month or longer visits)

- (i) Ruggiero Carli (Ph.D. student, ECE, University of Padova, Italy), Jan - Jun 2006
- (ii) Baris Fidan (Adjunct Research Fellow, Australian National University), Jun 2006
- (iii) Fabio Pasqualetti (MS student, University of Pisa, Italy), Oct 2006 - Jun 2007
- (iv) Giulia Piovan (MS student, University of Padova, Italy), Apr 2007 - Jun 2007
- (v) Fabio Morbidi (Ph.D. student, University of Siena, Italy), Oct 2007 - Apr 2008

Professional Service

Member, Board of Governors, IEEE Control Systems Society, Jan 2007 – Dec 2009
 Senior Member, IEEE, 2003-present (Member since 1994)
 Member, SIAM, 2000-present
 NSF Panelist, CMS 2002, 2004, and 2005, CISE 2005, ECS 2007. NSF Reviewer, 2005, 2006
 ARO Proposal Reviewer, 2005, 2006, 2007
 AFOSR Proposal Reviewer, 2005
 ASME/RSI Peer Review Panel, Office of Science and Technology, DOE, Jun 2001, Aug 2001
 Chair, Technical Committee on Manufacturing Automation and Robotic Control
 IEEE Control System Society, Jul 2004 - present

Editorships:

- Editorial Board, IEEE Transactions on Automatic Control, Jan 2005- Dec 2007
- Editorial Board, SIAM Journal of Control and Optimization, Jan 2005 - Dec 2010
- Editorial Board, ESAIM: Control, Optimization, and the Calculus of Variations, Jan 2003 - Dec 2006
- Conference Editorial Board, IEEE Control System Society, Sep 1999 - May 2005

Conference Co-Chair

IFAC Workshop Lagrangian & Hamiltonian Methods in Nonlinear Control, Nagoya, Jul 2006

Workshop Organizer or Organizing Committee:

- Workshop on “Cooperative MultiAgent Systems,” Centro De Giorgi, Pisa, Dec 2007
- MiniSymposium at SIAM Conference on Applications of Dynamical Systems, May 2005
- Workshop at IEEE Control and Decision Conference, Dec 2004
- ONR Workshop on Autonomous and Intelligent Systems, UIUC, May 2003
- Workshop on Nonlinear Control of Mechanical Systems, UIUC, Oct 2002
- MiniSymposium at SIAM Control Conference, Jul 2001
- IFAC Workshop on Lagrangian and Hamiltonian Methods, Princeton, Mar 2000
- Midwest Mechanical Motion Meeting, Fall 1999, 2000, 2001, 2002
- Workshop on Mechanics, Dynamics and Control, Caltech, Dec 1997

Program Committees:

- 2001, 2003 and 2007 IEEE American Control Conference
- 2003 IEEE/RSJ International Conf. on Intelligent Robots & Systems
- 2004, 2005, 2007 and 2008 IEEE Control and Decision Conference
- 2006 Mediterranean Conference on Control Applications
- 2006 IEEE International Conference on Robotics and Automation
- 2006 Robotics: Science and Systems Conference
- 2006 IFAC Workshop on Multivehicle Systems

Invited Session Organizer:

- American Control Conference, 2007
- IEEE Control and Decision Conference, 2000, 2002, 2004, 2005, 2007
- IEEE International Conference Robotics and Automation, Apr 2004
- Allerton Conf. Communication, Control, and Computing, Oct 2000, Oct 2001
- Joint Int’l Meeting AMS / Real Sociedad Matemática Española, Jun 2003

Reviewer for: IEEE TAC, IEEE CST, IEEE TRA, IFAC Automatica, IFAC Systems and Control Letters, ASME J.

Vibration and Acoustics, ASME J. Dynamic Systems, Measurement and Control, AIAA J. Guidance, Control, and Dynamics, SIAM J. Control and Optimization, AMS Mathematical Reviews (2002-2004), Int. J. of Control, Int. J. Robotics Research, J. of Robotic Systems, Int. J. of Computer Vision, IEEE/ASME J. Microelectromechanical Systems, Robotica; Springer Verlag and John Wiley & Sons.

University Service

UCSB:

College of Engineering, Member of the Executive Committee, Sep 2006 - Aug 2008
College of Engineering, Member of Recruitment and Diversity Committee, Jan 2007 - present
ME, ViceChair and Chair of the Graduate Program, Jul 2006 - June 2007
ME, Member of Graduate Committee, Sep 2005 - Jun 2006
CCDC, Organized of the Seminar Series, Spring '06
ME, Member of Honors and Awards Committee, Jul 2005 - Jun 2006
ME, Member of Space Committee, Jul 2004 - present

UIUC:

GE Teaching Committee, Fall 2000
GE Graduate Committee, Feb 1999 - Jun 2004
CSL Decision and Control Seminar Series, Feb 1999 - Jun 2004

Advancement to Candidacy and Ph.D. Committees membership since 2004:

Chaohong Cai, ECE, UCSB
Ravi Balasubramanian, ME, CMU
Prabir Barooah, ECE, UCSB
Michael Messina, ECE, UCSB
Symeon Grivopoulos, ME, UCSB
Yonggang Xu, ECE, UCSB
Keith Purvis, ME, UCSB
Maxim Subbotin, ECE, UCSB
James Riehl, ECE, UCSB
Diane Dai, ECE, UCSB
Nima Moshtagh, ECE, University of Pennsylvania

Selected Invited Lectures

- (2008): University of Siena, University of Pisa, UCLA
- (2007): University of Illinois, Georgia Tech (RSS Workshop on Robotic Sensor Networks), Australian National University (Canberra, ACT)
- (2006): University of California at Santa Cruz, UCLA (IPAM), Benelux Meeting on Systems and Control (Netherlands), HSCC (Santa Barbara), UCLA (Center for Systems, Dynamics and Control), Caltech, Boston University (NSF Workshop on Future Directions in Networked Sensing), Tokyo Institute of Technology (Japan)
- (2005): Universitat Autònoma de Barcelona (Spain), California Institute of Technology (Workshop on Control, Estimation, and Communication), UC Berkeley, University of Notre Dame (Workshop on Networked Embedded Sensing and Control), EPFL (Workshop on Networked Embedded Systems and Distributed Sensing)
- (2004): CNR Roma (Italy), Yale University, Boston University, Carnegie Mellon University, Ohio State University, Northwestern University
- (2003): University of Pisa (Italy), Kyoto University (Japan), UC Santa Barbara, Block Island Workshop on Co-operative Control, Wright-Patterson AFB, Stanford University, Honeywell, Virginia Tech, Caltech
- (2002): Old Dominion University, University of Maryland at College-Park, University of Illinois at Chicago, Queen's University in Kingston (Canada), University of Twente (Netherlands)
- (2001): California Institute of Technology, University of Pennsylvania, Massachusetts Institute of Technology, UC Santa Barbara, University of Padova (Italy)
- (2000): Queen's University in Kingston (Canada), Arizona State University, Washington University in St. Louis
- (1999): Mathematisches Forschungsinstitut Oberwolfach (Germany), University of Michigan, UC Berkeley, Washington University in St. Louis, Princeton University

Publication List

Manuscripts are listed in reverse chronological order. All manuscripts and related presentations are available electronically at <http://motion.mee.ucsb.edu>.

Books

- F. Bullo and A. D. Lewis. **Geometric Control of Mechanical Systems**, volume 49 of **Texts in Applied Mathematics**. Springer Verlag, New York, 2004. ISBN 0387221956
- F. Bullo and K. Fujimoto, editors. **Lagrangian and Hamiltonian Methods for Nonlinear Control 2006**, volume 366 of **Lecture Notes in Control and Information Sciences**, New York, 2007. Springer Verlag. ISBN 978-3-540-73889-3. Proceedings from the 3rd IFAC Workshop, Nagoya, Japan, July 2006

Journal Articles

- [39] S. Bopardikar, F. Bullo, and J. P. Hespanha. On discrete-time pursuit-evasion games with sensing limitations. **IEEE Transactions on Robotics**, November 2007. Conditionally Accepted (Submitted Nov 2007)
- [38] C. Gao, J. Cortés, and F. Bullo. Notes on averaging over acyclic digraphs and discrete coverage control. **Automatica**, 44(8), 2008
- [37] N. Nordkvist and F. Bullo. Control algorithms along relative equilibria of underactuated Lagrangian systems on Lie groups. **IEEE Transactions on Automatic Control**, November 2007. (Submitted Jan 2007) To appear
- [36] K. Savla, G. Notarstefano, and F. Bullo. Maintaining limited-range connectivity among second-order agents. **SIAM Journal on Control and Optimization**, 2007. To appear, (Submitted Nov 2006)
- [35] S. Susca, S. Martínez, and F. Bullo. Gradient algorithms for polygonal approximation of convex contours. **Automatica**, April 2007. To appear
- [34] A. Ganguli, J. Cortés, and F. Bullo. Multirobot rendezvous with visibility sensors in nonconvex environments. **IEEE Transactions on Robotics**, August 2007. (Submitted Nov 2006) Conditionally Accepted
- [33] K. Savla, F. Bullo, and E. Frazzoli. Traveling Salesperson Problems for a double integrator. **IEEE Transactions on Automatic Control**, 2007. (Submitted Nov 2006) To appear
- [32] K. Savla, E. Frazzoli, and F. Bullo. Traveling Salesperson Problems for the Dubins vehicle. **IEEE Transactions on Automatic Control**, 53(9), 2008. (Submitted Jun 2006) To appear
- [31] S. Susca, S. Martínez, and F. Bullo. Monitoring environmental boundaries with a robotic sensor network. **IEEE Transactions on Control Systems Technology**, 16(2), 2008. To appear
- [30] S. Martínez, F. Bullo, J. Cortés, and E. Frazzoli. On synchronous robotic networks – Part II: Time complexity of rendezvous and deployment algorithms. **IEEE Transactions on Automatic Control**, 52(12):2214–2226, 2007
- [29] S. Martínez, F. Bullo, J. Cortés, and E. Frazzoli. On synchronous robotic networks – Part I: Models, tasks and complexity. **IEEE Transactions on Automatic Control**, 52(12):2199–2213, 2007
- [28] F. Bullo and A. D. Lewis. Reduction, linearization, and stability of relative equilibria for mechanical systems on Riemannian manifolds. **Acta Applicandae Mathematicae**, 99(1):53–95, 2007
- [27] S. Martínez, J. Cortés, and F. Bullo. Motion coordination with distributed information. **IEEE Control Systems Magazine**, 27(4):75–88, 2007
- [26] J. Cortés, S. Martínez, and F. Bullo. Robust rendezvous for mobile autonomous agents via proximity graphs in arbitrary dimensions. **IEEE Transactions on Automatic Control**, 51(8):1289–1298, 2006
- [25] A. Ganguli, J. Cortés, and F. Bullo. Maximizing visibility in nonconvex polygons: Nonsmooth analysis and gradient algorithm design. **SIAM Journal on Control and Optimization**, 45(5):1657–1679, 2006
- [24] S. Martínez and F. Bullo. Optimal sensor placement and motion coordination for target tracking. **Automatica**, 42(4):661–668, 2006
- [23] F. Bullo and D. Liberzon. Quantized control via locational optimization. **IEEE Transactions on Automatic Control**, 51(1):2–13, 2006
- [22] J. Cortés and F. Bullo. Coordination and geometric optimization via distributed dynamical systems. **SIAM Journal on Control and Optimization**, 44(5):1543–1574, 2005
- [21] F. Bullo and A. D. Lewis. Low-order controllability and kinematic reductions for affine connection control systems. **SIAM Journal on Control and Optimization**, 44(3):885–908, 2005
- [20] J. Cortés, S. Martínez, and F. Bullo. Spatially-distributed coverage optimization and control with limited-range interactions. **ESAIM. Control, Optimisation & Calculus of Variations**, 11:691–719, 2005
- [19] M. W. Spong and F. Bullo. Controlled symmetries and passive walking. **IEEE Transactions on Automatic Control**, 50(7):1025–1031, 2005

- [18] F. Bullo. Trajectory design for mechanical systems: from geometry to algorithms. **European Journal of Control**, 10(5):397–410, 2004
- [17] W. T. Cerven, F. Bullo, and V. L. Coverstone. Vehicle motion planning with time-varying constraints. **AIAA Journal of Guidance, Control, and Dynamics**, 27(3):506–508, 2004
- [16] J. Cortés, S. Martínez, T. Karatas, and F. Bullo. Coverage control for mobile sensing networks. **IEEE Transactions on Robotics and Automation**, 20(2):243–255, 2004
- [15] S. Martínez, J. Cortés, and F. Bullo. Analysis and design of oscillatory control systems. **IEEE Transactions on Automatic Control**, 48(7):1164–1177, 2003
- [14] F. Bullo and A. D. Lewis. Kinematic controllability and motion planning for the snakeboard. **IEEE Transactions on Robotics and Automation**, 19(3):494–498, 2003
- [13] W. T. Cerven and F. Bullo. Constructive controllability algorithms for motion planning and optimization. **IEEE Transactions on Automatic Control**, 48(4):575–589, 2003
- [12] J. W. Melody, T. Başar, and F. Bullo. On nonlinear controllability of homogeneous systems linear in the controls. **IEEE Transactions on Automatic Control**, 48(1):139–143, 2003
- [11] J. Cortés, S. Martínez, and F. Bullo. On nonlinear controllability and series expansions for Lagrangian systems with dissipative forces. **IEEE Transactions on Automatic Control**, 47(8):1396–1401, 2002
- [10] F. Bullo and M. Žefran. On mechanical control systems with nonholonomic constraints and symmetries. **Systems & Control Letters**, 45(2):133–143, 2002
- [9] F. Bullo and M. Žefran. Modeling and controllability for a class of hybrid mechanical systems. **IEEE Transactions on Robotics and Automation**, 18(4):563–573, 2002
- [8] F. Bullo. Series expansions for analytic systems linear in controls. **Automatica**, 38(9):1425–1432, 2002
- [7] F. Bullo. Averaging and vibrational control of mechanical systems. **SIAM Journal on Control and Optimization**, 41(2):542–562, 2002
- [6] F. Bullo and K. M. Lynch. Kinematic controllability for decoupled trajectory planning in underactuated mechanical systems. **IEEE Transactions on Robotics and Automation**, 17(4):402–412, 2001
- [5] F. Bullo. Series expansions for the evolution of mechanical control systems. **SIAM Journal on Control and Optimization**, 40(1):166–190, 2001
- [4] F. Bullo. Stabilization of relative equilibria for underactuated systems on Riemannian manifolds. **Automatica**, 36(12):1819–1834, 2000
- [3] F. Bullo, N. E. Leonard, and A. D. Lewis. Controllability and motion algorithms for underactuated Lagrangian systems on Lie groups. **IEEE Transactions on Automatic Control**, 45(8):1437–1454, 2000
- [2] F. Bullo and R. M. Murray. Tracking for fully actuated mechanical systems: A geometric framework. **Automatica**, 35(1):17–34, 1999
- [1] E. Masry and F. Bullo. Convergence analysis of the sign algorithm for adaptive filtering. **IEEE Transactions on Information Theory**, 41(2):489–495, 1995

Book Chapters

- [9] S. L. Smith and F. Bullo. A geometric assignment problem for robotic networks. In A. Chiuso, A. Ferrante, and S. Pinzoni, editors, **Modeling, Estimation and Control: Festschrift in Honor of Giorgio Picci on the Occasion of his Sixty-Fifth Birthday**, volume 364 of **Lecture Notes in Control and Information Sciences**, pages 271–284. Springer Verlag, 2007. ISBN 978-3-540-73569-4
- [8] A. Ganguli, J. Cortés, and F. Bullo. Distributed coverage of nonconvex environments. In V. Saligrama, editor, **Networked Sensing Information and Control (Proceedings of the NSF Workshop on Future Directions in Systems Research for Networked Sensing, May 2006, Boston, MA)**, Lecture Notes in Control and Information Sciences, pages 289–305. Springer Verlag, 2007. ISBN 0387688439
- [7] K. Savla, E. Frazzoli, and F. Bullo. On the Dubins Traveling Salesperson Problems: Novel approximation algorithms. In G. S. Sukhatme, S. Schaal, W. Burgard, and D. Fox, editors, **Robotics: Science and Systems II (Proceedings of the Second RSS Conference, August 2006, Philadelphia PA)**. MIT Press, Cambridge, MA, 2007. ISBN 0262693488. Available electronically at <http://arxiv.org/abs/cs.RO/0603010>
- [6] F. Bullo. Notes on multi-agent motion coordination: Models and algorithms. In P. J. Antsaklis and P. Tabuada, editors, **Network Embedded Sensing and Control. (Proceedings of NESC'05 Workshop)**, volume 331 of **Lecture Notes in Control and Information Sciences**, pages 3–8. Springer Verlag, New York, 2006. ISBN 3540327940
- [5] M. Žefran and F. Bullo. Lagrangian dynamics. In T. R. Kurfess, editor, **Robotics and Automation Handbook**, chapter 5. CRC Press, Boca Raton, FL, 2004. ISBN 0849318041
- [4] F. Bullo and J. Cortés. Adaptive and distributed coordination algorithms for mobile sensing networks. In V. Kumar, N. E. Leonard, and A. S. Morse, editors, **Cooperative Control. (Proceedings of the 2003 Block Island Workshop on Cooperative Control)**, volume 309 of **Lecture Notes in Control and Information Sciences**, pages 43–62. Springer Verlag, New York, 2005. ISBN 3540228616

- [3] F. Bullo, J. Cortés, A. D. Lewis, and S. Martínez. Vector-valued quadratic forms in control theory. In V. Blondel and A. Megretski, editors, **Unsolved Problems in Mathematical Systems and Control Theory**, pages 315–320. Princeton University Press, Princeton, NJ, 2004. ISBN 0691117489
- [2] F. Bullo. Trajectory design for mechanical systems: from geometry to algorithms. In A. Astolfi, F. Gordillo, and A. J. van der Schaft, editors, **Lagrangian and Hamiltonian Methods in Nonlinear Control 2003 (A Proceedings Volume from the 2nd IFAC Workshop, Seville, Spain, April 2003)**, pages 1–16. Elsevier, Oxford, UK, 2003. ISBN 0080442781
- [1] S. Martínez, J. Cortés, and F. Bullo. Motion planning and control problems for underactuated robots. In A. Bicchi, H. Christensen, and D. Prattichizzo, editors, **Control Problems in Robotics**, volume 4 of **Springer Tracts in Advanced Robotics**, pages 59–74. Springer Verlag, New York, 2003. ISBN 3540002510

Under Review

- [4] R. Carli and F. Bullo. Quantized coordination algorithms for rendezvous and deployment. **SIAM Journal on Control and Optimization**, December 2007. Submitted
- [3] S. L. Smith and F. Bullo. Monotonic target assignment for robotic networks. **IEEE Transactions on Automatic Control**, June 2007. Submitted
- [2] K. Plarre and F. Bullo. On Kalman filtering for detectable systems with intermittent observations. **IEEE Transactions on Automatic Control**, May 2007. Submitted
- [1] F. Bullo, J. Cortés, and S. Martínez. Distributed algorithms for robotic networks. In R. Meyers, editor, **Encyclopedia of Complexity and Systems Science**. Springer Verlag, 2008. To appear

Refereed Conference Publications

- [77] G. Piovan, I. Shames, B. Fidan, B. D. O. Anderson, and F. Bullo. On frame and orientation localization for relative sensing networks. In **IEEE Conf. on Decision and Control**, Cancun, Mexico, December 2008. Submitted
- [76] J. W. Durham and F. Bullo. Smooth nearness-diagram navigation. In **IEEE/RSJ Int. Conf. on Intelligent Robots & Systems**, Nice, France, September 2008. Submitted
- [75] S. D. Bopardikar, F. Bullo, and J. P. Hespanha. A pursuit game with range-only measurements. In **IEEE Conf. on Decision and Control**, Cancun, Mexico, December 2008. Submitted
- [74] S. L. Smith and F. Bullo. Dynamic multi-agent team forming: Asymptotic results on throughput versus delay. In **American Control Conference**, Seattle, WA, June 2008. To appear
- [73] M. Schwager, F. Bullo, D. Skelly, and D. Rus. A ladybug exploration strategy for distributed adaptive coverage control. In **IEEE Int. Conf. on Robotics and Automation**, Pasadena, CA, May 2008. To appear
- [72] M. Pavone, E. Frazzoli, and F. Bullo. Decentralized algorithms for stochastic and dynamic vehicle routing with general target distribution. In **IEEE Conf. on Decision and Control**, pages 4869–4874, New Orleans, LA, December 2007
- [71] S. L. Smith and F. Bullo. Target assignment for robotic networks: Worst-case and stochastic performance in dense environments. In **IEEE Conf. on Decision and Control**, pages 3585–3590, New Orleans, LA, December 2007 (**Best Student Paper Award Finalist**)
- [70] S. D. Bopardikar, F. Bullo, and J. P. Hespanha. A cooperative Homicidal Chauffeur game. In **IEEE Conf. on Decision and Control**, pages 4857–4862, New Orleans, LA, December 2007
- [69] N. Nordkvist and F. Bullo. Control algorithms along relative equilibria of underactuated Lagrangian systems on Lie groups. In **IEEE Conf. on Decision and Control**, pages 6232–6237, New Orleans, LA, December 2007
- [68] S. Susca, F. Bullo, and S. Martínez. Synchronization of beads on a ring. In **IEEE Conf. on Decision and Control**, pages 4845–4850, New Orleans, LA, December 2007
- [67] K. Savla, F. Bullo, and E. Frazzoli. The coverage problem for loitering Dubins vehicles. In **IEEE Conf. on Decision and Control**, pages 1398–1403, New Orleans, LA, December 2007
- [66] G. Notarstefano and F. Bullo. Network abstract linear programming with application to minimum-time formation control. In **IEEE Conf. on Decision and Control**, pages 927–932, New Orleans, LA, December 2007
- [65] F. Pasqualetti, A. Bicchi, and F. Bullo. Distributed intrusion detection for secure consensus computations. In **IEEE Conf. on Decision and Control**, pages 5594–5599, New Orleans, LA, December 2007
- [64] K. J. Obermeyer, A. Ganguli, and F. Bullo. Asynchronous distributed searchlight scheduling. In **IEEE Conf. on Decision and Control**, pages 4863–4868, New Orleans, LA, December 2007
- [63] A. Ganguli, J. Cortés, and F. Bullo. Visibility-based multi-agent deployment in orthogonal environments. In **American Control Conference**, pages 3426–3431, New York, July 2007
- [62] S. L. Smith and F. Bullo. Target assignment for robotic networks: Asymptotic performance under limited communication. In **American Control Conference**, pages 1155–1160, New York, July 2007
- [61] S. D. Bopardikar, F. Bullo, and J. P. Hespanha. Cooperative pursuit with sensing limitations. In **American Control Conference**, pages 5394–5399, New York, July 2007
- [60] S. D. Bopardikar, F. Bullo, and J. P. Hespanha. Sensing limitations in the Lion and Man problem. In **American Control Conference**, pages 5958–5963, New York, July 2007

- [59] K. Savla and F. Bullo. On the time complexity of formation control. In **Allerton Conference on Communications, Control and Computing**, pages 1310–1314, September 2006
- [58] G. Notarstefano and F. Bullo. Distributed consensus on enclosing shapes and minimum time rendezvous. In **IEEE Conf. on Decision and Control**, pages 4295–4300, San Diego, CA, December 2006
- [57] K. Savla, F. Bullo, and E. Frazzoli. On Traveling Salesperson Problems for a double integrator. In **IEEE Conf. on Decision and Control**, pages 5305–5310, San Diego, CA, December 2006
- [56] C. Gao, F. Bullo, J. Cortés, and A. Jadbabaie. Notes on averaging over acyclic digraphs and discrete coverage control. In **IEEE Conf. on Decision and Control**, pages 4651–4656, San Diego, CA, December 2006
- [55] S. Susca, S. Martínez, and F. Bullo. Distributed algorithms for polygonal approximation of convex contours. In **IEEE Conf. on Decision and Control**, pages 6512–6517, San Diego, CA, December 2006
- [54] G. Notarstefano, K. Savla, F. Bullo, and A. Jadbabaie. Maintaining limited-range connectivity among second-order agents. In **American Control Conference**, pages 2124–2129, Minneapolis, MN, June 2006
- [53] S. Susca, S. Martínez, and F. Bullo. Monitoring environmental boundaries with a robotic sensor network. In **American Control Conference**, pages 2072–2077, Minneapolis, MN, June 2006
- [52] A. Ganguli, J. Cortés, and F. Bullo. Distributed deployment of asynchronous guards in art galleries. In **American Control Conference**, pages 1416–1421, Minneapolis, MN, June 2006 (**Best Student Paper Award**)
- [51] J. J. Enright, E. Frazzoli, K. Savla, and F. Bullo. On multiple UAV routing with stochastic targets: performance bounds and algorithms. In **AIAA Conf. on Guidance, Navigation and Control**, August 2005. Electronic Proceedings
- [50] A. Ganguli, S. Susca, S. Martínez, F. Bullo, and J. Cortés. On collective motion in sensor networks: Sample problems and distributed algorithms. In **IEEE Conf. on Decision and Control and European Control Conference**, pages 4239–4244, Seville, Spain, December 2005
- [49] K. Savla, F. Bullo, and E. Frazzoli. On traveling salesperson problems for Dubins’ vehicle: stochastic and dynamic environments. In **IEEE Conf. on Decision and Control and European Control Conference**, pages 4530–4535, Seville, Spain, December 2005 (**Best Student Paper Award Finalist**)
- [48] A. Ganguli, J. Cortés, and F. Bullo. On rendezvous for visually-guided agents in a nonconvex polygon. In **IEEE Conf. on Decision and Control and European Control Conference**, pages 5686–5691, Seville, Spain, December 2005
- [47] S. Martínez, F. Bullo, J. Cortés, and E. Frazzoli. On synchronous robotic networks – Part II: Time complexity of rendezvous and deployment algorithms. In **IEEE Conf. on Decision and Control and European Control Conference**, pages 8313–8318, Seville, Spain, December 2005
- [46] S. Martínez, F. Bullo, J. Cortés, and E. Frazzoli. On synchronous robotic networks – Part I: Models, tasks and complexity notions. In **IEEE Conf. on Decision and Control and European Control Conference**, pages 2047–2852, Seville, Spain, December 2005
- [45] A. Ganguli, J. Cortés, and F. Bullo. Maximizing visibility in nonconvex polygons: Nonsmooth analysis and gradient algorithm design. In **American Control Conference**, pages 792–797, Portland, OR, June 2005 (**Best Student Paper Award Finalist**)
- [44] K. Savla, E. Frazzoli, and F. Bullo. On the point-to-point and traveling salesperson problems for Dubins’ vehicle. In **American Control Conference**, pages 786–791, Portland, OR, June 2005
- [43] J. Cortés, S. Martínez, and F. Bullo. Analysis and design tools for distributed motion coordination. In **American Control Conference**, pages 1680–1685, Portland, OR, June 2005
- [42] S. Martínez, J. Cortés, and F. Bullo. On robust rendezvous for mobile autonomous agents. In **IFAC World Congress**, Prague, Czech Republic, July 2005. Electronic Proceedings
- [41] S. E. Aranda, S. Martínez, and F. Bullo. On optimal sensor placement and motion coordination for target tracking. In **IEEE Int. Conf. on Robotics and Automation**, pages 4544–4549, Barcelona, Spain, April 2005
- [40] E. Frazzoli and F. Bullo. Decentralized algorithms for vehicle routing in a stochastic time-varying environment. In **IEEE Conf. on Decision and Control**, pages 3357–3363, Paradise Island, Bahamas, December 2004
- [39] J. Cortés, S. Martínez, and F. Bullo. Coordinated deployment of mobile sensing networks with limited-range interactions. In **IEEE Conf. on Decision and Control**, pages 1944–1949, Paradise Island, Bahamas, December 2004
- [38] C. L. Robinson, D. Block, S. Brennan, F. Bullo, and J. Cortés. Nonsmooth analysis and sonar-based implementation of distributed coordination algorithms. In **IEEE Int. Conf. on Robotics and Automation**, pages 3000–3005, New Orleans, LA, April 2004
- [37] F. Bullo and D. Liberzon. On quantized control and geometric optimization. In **IEEE Conf. on Decision and Control**, pages 2567–2572, Maui, HI, December 2003
- [36] J. Cortés and F. Bullo. From geometric optimization and nonsmooth analysis to distributed coordination algorithms. In **IEEE Conf. on Decision and Control**, pages 3274–3280, Maui, HI, December 2003
- [35] S. Martínez, J. Cortés, and F. Bullo. A catalog of inverse-kinematics planners for underactuated systems on matrix Lie groups. In **IEEE/RSJ Int. Conf. on Intelligent Robots & Systems**, pages 625–630, Las Vegas, NV, October 2003
- [34] S. Martínez, J. Cortés, and F. Bullo. Design of oscillatory control systems. In **IEEE Conf. on Decision and Control**, pages 1509–1514, Las Vegas, NV, December 2002 (**Best Student Paper Award**)
- [33] E. Frazzoli and F. Bullo. On quantization and optimal control of dynamical systems with symmetries. In **IEEE Conf. on Decision and Control**, pages 817–823, Las Vegas, NV, December 2002

- [32] F. Bullo, J. Cortés, A. D. Lewis, and S. Martínez. Vector-valued quadratic forms in control theory. In **Mathematical Theory of Networks and Systems**, South Bend, IN, August 2002. Electronic Proceedings
- [31] F. Bullo, A. D. Lewis, and K. M. Lynch. Controllable kinematic reductions for mechanical systems: concepts, computational tools, and examples. In **Mathematical Theory of Networks and Systems**, South Bend, IN, August 2002
- [30] J. Cortés, S. Martínez, T. Karatas, and F. Bullo. Coverage control for mobile sensing networks: variations on a theme. In **Mediterranean Conference on Control and Automation**, Lisbon, Portugal, July 2002. Electronic Proceedings
- [29] S. Martínez, J. Cortés, and F. Bullo. Analysis of oscillatory control systems. In **IFAC World Congress**, Barcelona, Spain, July 2002. Electronic Proceedings
- [28] M. W. Spong and F. Bullo. Controlled symmetries and passive walking. In **IFAC World Congress**, Barcelona, Spain, July 2002. Electronic Proceedings
- [27] F. Bullo and M. Žefran. On mechanical control systems with nonholonomic constraints and symmetries. In **IEEE Int. Conf. on Robotics and Automation**, pages 1741–1746, Arlington, VA, May 2002 (**Best Paper Award Finalist**)
- [26] J. Cortés, S. Martínez, T. Karatas, and F. Bullo. Coverage control for mobile sensing networks. In **IEEE Int. Conf. on Robotics and Automation**, pages 1327–1332, Arlington, VA, May 2002
- [25] M. Žefran, F. Bullo, and M. Stein. A notion of passivity for hybrid systems. In **IEEE Conf. on Decision and Control**, pages 768–773, Orlando, FL, December 2001
- [24] T. Karatas and F. Bullo. Randomized searches and nonlinear programming in trajectory planning. In **IEEE Conf. on Decision and Control**, pages 5032–5037, Orlando, FL, December 2001
- [23] J. Cortés, S. Martínez, and F. Bullo. On nonlinear controllability and series expansions for Lagrangian systems with damping. In **IEEE Conf. on Decision and Control**, pages 2619–2624, Orlando, FL, December 2001
- [22] F. Bullo and K. M. Lynch. Kinematic controllability and decoupled trajectory planning for underactuated mechanical systems. In **IEEE Int. Conf. on Robotics and Automation**, pages 3300–3307, Seoul, Korea, April 2001
- [21] G. J. Toussaint, T. Başar, and F. Bullo. Motion planning for nonlinear underactuated vehicles using H^∞ techniques. In **American Control Conference**, pages 4907–4102, Arlington, VA, June 2001
- [20] J. W. Melody, T. Başar, and F. Bullo. On nonlinear controllability of homogeneous systems linear in the controls. In **IEEE Conf. on Decision and Control**, pages 3971–3976, Sydney, Australia, December 2000
- [19] G. J. Toussaint, T. Başar, and F. Bullo. H^∞ -optimal tracking control techniques for nonlinear underactuated systems. In **IEEE Conf. on Decision and Control**, pages 2078–2083, Sydney, Australia, December 2000
- [18] F. Bullo and A. D. Lewis. On the homogeneity of the affine connection model for mechanical control systems. In **IEEE Conf. on Decision and Control**, pages 1260–1265, Sydney, Australia, December 2000
- [17] F. Bullo. Series expansions for analytic systems linear in the controls. In **IEEE Conf. on Decision and Control**, pages 3392–3397, Sydney, Australia, December 2000
- [16] F. Bullo and W. T. Cerven. On trajectory optimization for polynomial systems via series expansions. In **IEEE Conf. on Decision and Control**, pages 772–777, Sydney, Australia, December 2000
- [15] G. J. Toussaint, T. Başar, and F. Bullo. Tracking for nonlinear underactuated surface vessels with generalized forces. In **IEEE Conf. on Control Applications**, pages 355–360, Anchorage, AK, September 2000
- [14] F. Bullo. On perturbation methods for mechanical control systems. In N. E. Leonard and R. Ortega, editors, **Proceedings of the First IFAC Workshop on Lagrangian and Hamiltonian Methods for Nonlinear Control**, pages 163–164, Princeton, NJ, March 2000
- [13] M. Žefran, F. Bullo, and J. Radford. An investigation into non-smooth locomotion. In **IEEE Int. Conf. on Robotics and Automation**, pages 2038–2043, Detroit, MI, May 1999
- [12] F. Bullo. Stabilization of relative equilibria for systems on Riemannian manifolds. In **American Control Conference**, pages 1618–1622, San Diego, CA, June 1999
- [11] F. Bullo. A series describing the evolution of mechanical control systems. In **IFAC World Congress**, volume 6, pages 479–485, Beijing, China, July 1999
- [10] F. Bullo and M. Žefran. On modeling and locomotion of hybrid mechanical systems with impacts. In **IEEE Conf. on Decision and Control**, pages 2633–2638, Tampa, FL, December 1998
- [9] F. Bullo. Exponential stabilization of relative equilibria for mechanical systems with symmetries. In **Mathematical Theory of Networks and Systems**, pages 987–990, Padova, Italy, July 1998
- [8] F. Bullo and N. E. Leonard. Motion primitives for stabilization and control of underactuated vehicles. In **IFAC Symposium on Nonlinear Control Systems**, volume 1, pages 133–138, Enschede, the Netherlands, July 1998
- [7] F. Bullo and R. M. Murray. Trajectory tracking for fully actuated mechanical systems. In **European Control Conference**, page 707, Brussels, Belgium, July 1997
- [6] F. Bullo and N. E. Leonard. Motion control for underactuated mechanical systems on Lie groups. In **European Control Conference**, page 480, Brussels, Belgium, July 1997
- [5] F. Bullo and R. M. Murray. Experimental comparison of trajectory trackers for a car with trailers. In **IFAC World Congress**, volume F, pages 407–412, San Francisco, CA, July 1996
- [4] F. Bullo and A. D. Lewis. Configuration controllability of mechanical systems on Lie groups. In **Mathematical Theory of Networks and Systems**, St. Louis, MO, June 1996
- [3] F. Bullo and R. M. Murray. Proportional derivative (PD) control on the Euclidean group. In **European Control Conference**, volume 2, pages 1091–1097, Rome, Italy, June 1995

- [2] F. Bullo, R. M. Murray, and A. Sarti. Control on the sphere and reduced attitude stabilization. In **IFAC Symposium on Nonlinear Control Systems**, volume 2, pages 495–501, Tahoe City, CA, June 1995
- [1] E. Masry and F. Bullo. Performance analysis of adaptive filters using the sign algorithm. In **IEEE International Symposium on Information Theory**, page 360, Trondheim, Norway, June 1994

Research Funding

Completed Projects

- (i) University of Illinois Research Board, *Stability and Locomotion in Robotic Mechanisms and Autonomous Vehicles*, F. Bullo, 1/99 – 01/00.
- (ii) Army Research Office, DAAD 190110716, *Trajectories for Locomotion Systems: A Geometric and Computational Approach via Series Expansions*, F. Bullo, 9/01–8/04.
- (iii) National Science Foundation, Robotics and Human Augmentation Program, IIS-0118146, *Algorithmic and Differential-Geometric Trajectory Design*. F. Bullo (PI) and S. M. Lavalley (Co-PI), 9/01–8/04.
- (iv) National Science Foundation, Dynamic Systems and Control Program, CMS-0100162, *Perturbation Methods for Nonlinear Control of Lagrangian Systems*, F. Bullo, 9/01–8/04.
- (v) National Science Foundation, Control, Networks, and Computational Intelligence Program, ECS-0122412, *Layered Architectures for Complex Networked Systems*, M. W. Spong (PI), F. Bullo (Co-PI), 9/01–8/04.
- (vi) University of Illinois Initiative in Trustworthy Networked Systems, *AeroTruNet: A Trustworthy Networked Aerospace System*, E. Frazzoli (PI), F. Bullo (Co-PI), 10/02–10/03.
- (vii) Office of Naval Research, Mathematical, Computer, and Information Sciences Division, FY03 Young Investigator Program, N00014-03-1-0512, *Distributed and Adaptive Coordination Algorithms for Mobile Sensing Networks*, F. Bullo, 6/03–5/06.
- (viii) Defense Advanced Research Projects Agency and Air Force Office of Scientific Research, MURI Program, F49620-02-1-0325, *Cooperative Networked Control of Dynamical Peer-to-Peer Vehicle Systems*, Consortium of UIUC (lead), Stanford, MIT, G.E. Dullerud (PI), F. Bullo (Co-PI), 5/02–8/07.
- (ix) National Science Foundation, Dynamic Systems and Control Program, CMS-0442041 (former CMS-0301423) *Collaborative Research: Kinematic Reductions for Underactuated Mechanical Systems*, F. Bullo, 9/03 – 8/07.

Current Projects

- (i) National Science Foundation, Robotics and Human Augmentation Program, IIS-0525543 (former IIS-0330008) *SENSORS: Cooperative Robotics and Geometric Optimization for Mobile Sensors*, F. Bullo, 9/03 – 8/08.
- (ii) Army Research Office, MURI Program, W911NF-05-1-0219, *Scalable Swarms of Autonomous Robots and Sensors*, Consortium of UPenn (lead), UC Santa Barbara, MIT, Yale, UC Berkely, V. Kumar (PI), F. Bullo (Co-PI), 5/05–4/10.
- (iii) National Science Foundation, Dynamic Systems and Control Program, CMS-0626457 *Distributed Illumination Problems for Visually-guided Agents*, F. Bullo, 9/06 – 8/09.
- (iv) Office of Naval Research, Mathematical, Computer, and Information Sciences Division, N00014-07-1-0721, *Algorithmic Coordination in Robotic Networks*, F. Bullo, 1/07–12/09.
- (v) Army Research Office, Institute for Collaborative Biotechnology, *Bio-inspired Stochastic Search and Decision Making for Robotic Networks*, F. Bullo and J. Moehlis, 6/07–6/09.
- (vi) Air Force Office of Scientific Research, MURI Program, *Behavioral Dynamics in the Cooperative Control of Mixed Human/Robotics Teams*, Consortium of BU (lead), Princeton, University of Washington, UCSB, J. Baillieul (PI), F. Bullo (Co-PI), 5/07–4/13.