

## Ian A. Gravagne

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### Education

#### **Ph.D. in Electrical Engineering**

Clemson University, Clemson, SC, August 2002

Dissertation: "*Design, Analysis and Experimentation: the Fundamentals of Continuum Robotic Manipulators.*" Dissertation Advisor: Dr. Ian D. Walker

#### **M.S. in Electrical Engineering**

Clemson University, Clemson, SC, May 1999

Thesis: "*Minimum Effort Techniques for Inverse Kinematics of Redundant Robot Manipulators.*" Thesis Advisor: Dr. Ian D. Walker

#### **B.S. in Electrical Engineering**

Rice University, Houston, TX, May 1997

Concentrations: Signals and Systems, Semiconductors

### Academic Appointments

#### **Associate Professor**

Baylor University, Dept. of Electrical and Computer Engineering, August 2008 – present

#### **Assistant Professor**

Baylor University, Dept. of Electrical and Computer Engineering, August 2002 – August 2008

#### **Instructor of Record**

Clemson University, Dept. of Electrical and Computer Engineering, August 2001 – May 2002

#### **Graduate Research Assistant**

Clemson University, Electrical and Computer Engineering Department, August 1997 – August 2002

### External Funding

- National Science Foundation, ECCS-801440, "Multi-Agent Systems Based Intelligent Distributed Control System for Power Plants," \$330,000, Dr. Kwang Lee (PI), Dr. Ian Gravagne, Dr. Robert Marks, June 2008 – June 2011
- National Science Foundation, DUE-736742, "Engaged Learning Groups: Building Community While Learning About Energy," \$145,477, Dr. Ian Gravagne (PI), Dr. Kenneth Van Treuren, June 2008 – June 2011
- National Science Foundation, CMMI-726996, " $\mu$ -Dynamics on Time Scales: Adaptive Time Domains for Dynamical Systems," \$143,952, Dr. Ian Gravagne (PI), Dr. John Davis, Dr. Robert Marks, Sept 2007 – Sept 2010
- Baylor/Waco Foundation and BP Energy, "An Alternative Energy Laboratory Exhibit in the Mayborn Museum," \$31,300, Dr. Ian Gravagne (PI), Dr. Ellie Caston and Dr. Ken Van Treuren, Dec 2006 – Dec 2007
- National Science Foundation, REU supplement, \$11,000, Dr. Ian Gravagne (PI), Dr. John Davis, Dr. Robert Marks, summer 2005, 2006

- National Science Foundation, CNS-410685, “Real-Time Distributed Control Networks: Dynamic Bandwidth Allocation via Adaptive Sampling,” \$300,000, Dr. Ian Gravagne (PI), Dr. John Davis, Dr. Robert Marks, Sept 2004 – Sept 2008
- Curves International, “Development of Next Generation Exercise Equipment,” \$893,469, Dr. Walter Bradley (PI), Dr. Brian Garner, Dr. Ian Gravagne, Aug 2004 – Dec 2006
- South Carolina NASA Space Grant Consortium Fellowship \$20,000/year, 2001, 2002
- South Carolina NASA Space Grant Consortium Scholarship \$3,000/year, 1998, 1999, 2000

### **Internal Funding**

- SACS/QEP/ELG initiative, “Energy and Society: The Costs and Benefits of an Energy-Dependent Civilization,” \$52,816, Dr. Ian Gravagne (PI), Dr. Ken Van Treuren, Dr. Larry Lehr, Aug 2007 – May 2009
- Baylor University Research Council, “Study of the Engineering Applications of Time-Scales,” \$6,000, Dr. John Davis and Dr. Ian Gravagne, summer 2003

### **Honors and Awards**

- Senior Member, IEEE
- Outstanding Professor for Scholarship and Research, Baylor University, 2010
- Achievement Award for New Scholars in Mathematics, Physical Sciences and Engineering, Council of Southern Graduate Schools (CSGS), 2008
- Big XII Rising Star, Big XII Center for Economic Development, Innovation and Commercialization, 2007
- Outstanding Professor for Scholarship and Research, Baylor University, 2005
- Outstanding Graduate Researcher, Clemson University, 2002
- Outstanding Graduate Researcher, Clemson College of Engineering and Science, 2001
- Outstanding Graduate Researcher, Clemson Electrical and Computer Engineering Dept., 2001
- Finalist, Anton Philips Outstanding Graduate Student Paper, 2000 IEEE International Conference on Robotics and Automation, San Francisco, CA
- Alpha-Epsilon-Lambda National Graduate Student Honor Society
- Eta-Kappa-Nu National Electrical Engineering Honor Society

### **Professional and Academic Service**

- Director, SACS/QEP “Engaged Learning Groups,” 2009 – present
- Co-organizer, special session on Time Scales and Applications, 1051<sup>st</sup> meeting of the AMS, Baylor University, 2009
- Chair, ECE Search Committee for new department head
- Baylor University, University Honor Council
- Baylor University, Graduate Faculty Member
- Board of Trustees, Brooks Residential College, 2008 – 2010
- Advisory Board, Engineering and Computer Science Living/Learning Center, 2007 – present
- Fundamentals of Engineering professional engineer examination proctor, 2005, 2007, 2008, 2009
- Proposal Reviewer, DEPSCoR, States of Kansas and Alabama
- Technical Reviewer, e.g. IEEE Transactions on Robotics and Automation; IEEE Transactions on Systems, Man and Cybernetics; IEEE/ASME Transactions on Mechatronics; IEEE Transactions on Automatic Control; IEEE Transactions on Automation Science and Engineering; Transactions of the Society of Modeling and Simulation International; Journal of Smart Materials and

Structures; Journal of Dynamic Systems, Measurement and Control; Journal of Applied Bionics and Biomechanics; Nonlinear Analysis Series B: Real World Applications; ASME Journal of Mechanical Design

- Session Chair
  - 2005 Int. Conf. on Intelligent Systems and Robots, Edmonton, Canada.
  - 2001 Int. Conf. on Intelligent Systems and Robots, Maui, HI (Kinematics, Internet Robots, Robot Vision, Robot Sensing and Robot Simulation)
  - 2000 Int. Conf. on Robotics and Automation, San Francisco, CA (Robot Kinematics)
  - Space and Robotics 2000 Conference, Albuquerque, NM (Novel Devices)

## Graduate Students

- Eric Johns, in progress
- Jason Gomes, in progress
- John Miller, MSECE, “Stability of Non-Diagonalizable Switched Linear Systems on Time Scales,” May 2009.
- Kirk Bolton, MSECE, “Design of a Solar Collector Thermal Simulator,” December 2008.
- Chris Matcek, ME, “Design of a Phantom Load Controller for Entertainment Centers,” December 2008.
- Ben Allen, MSECE, “Experimental Investigation of a Time Scales Linear Feedback Control Theorem,” August 2007.
- Janna Morris, MSECE, “A Networked Embedded Design for an Automated Exercise System,” May 2007.
- Walt Ford, MSECE, “Development and Implementation of a Real-Time Distributed Network with the CAN protocol,” December 2005.
- Brett Levins, MSECE, “A Magnetically Controllable Valve to Vary the Resistance of Hydraulic Dampers in Exercise Equipment,” August 2005.

## Courses Taught

- *EGR 4396 (Solar Energy Engineering)*: A lecture course on topics related to the analysis and design of solar energy systems, including earth-sun geometry, atmospheric, solar PV and solar thermal design. Offered to electrical and mechanical engineers, to arm engineers with technical skills to meet rising energy challenges in industrialized countries.
- *EGR 4390 (Engineering Design II)*: A laboratory course. Responsibilities are to seek industrial project sponsorship, give technical advice and assistance to students as they complete the project, serve as liaison between Baylor and sponsoring company. Intent is to simulate a business environment, with 10 to 20 students operating as a single “company” with several “departments” and a realistic management and assessment structure.
- *EGR 4330 (Introduction to Robotics)*: A lecture and laboratory course covering the fundamentals of classical robotics, including kinematics, dynamics, control, path planning, etc., as well as some nontraditional topics including distributed and embedded control, real-time operating systems and software, and networked robots.
- *EGR 5302 (Engineering Analysis)*: A lecture course designed to raise the mathematical abilities of beginning graduate engineering students. Topics cover introductory functional analysis, advanced linear algebra, introductory variational calculus and select numerical solution techniques for PDE’s involving energy methods.
- *EGR 5332 (Nonlinear Analysis and Control)*: A lecture/laboratory course on some advanced concepts in control. Focused on transferring classroom knowledge into working systems. Emphasizes topics related to embedded technologies, e.g. fixed point feedback control algorithms and distributed control networks.

- *ECE 201 (Clemson University; Logic and Computing Devices)*: A lecture/laboratory course covering an introduction to Boolean algebra, number systems, digital representation of information, use of integrated circuits to implement combinational and sequential logic, and organization and structure of computing systems.

## Research Areas

- *Dynamic Equations on Time Scales*: A relatively new branch of mathematics, DETS is finding application to engineering problems and is also a relevant area of study in itself. Research is focused on developing the theoretical foundations of DETS (e.g. integral transforms, theorems for system controllability, Lyapunov tools) that will make it useful for modeling and designing dynamical systems on non-uniform time domains, such as those found in distributed control networks and other so-called “cyber-physical systems.” In essence, DETS is a tool that can help engineers to model complex systems on the temporal and spatial domains that are natural for them, rather than trying to cast engineering problems to fit existing mathematical frameworks.
- *Power and Energy*: Work here consists of several thrusts.
  - Power plant control: Investigating techniques, such as the use of multi-agent systems, to better control coal-fired power plants in the presence of uncertainty from stochastic generators on the grid, including solar and wind power.
  - Solar energy: Investigating methods to increase the accuracy of metering thermal solar systems. Currently, energy input metering requires the computation of a temperature difference that is often fairly small. By measuring input and output temperatures on separate channels and then subtracting, measurement/sensor error can swamp the thermal power calculation. Research in this area is also focused on the design of more efficient Maximum Power Point Tracking algorithms and switching power electronics.
  - Energy Literacy: Work investigating ways to increase the technical and social comprehension of energy and sustainability through new and existing curricula and public service projects. Three focus areas are public education (e.g. design and construction of energy-related exhibits in Baylor University’s Mayborn museum), university interdisciplinary education (e.g. the two-year Engaged Learning Group [ELG] sponsored by Baylor) and community outreach (e.g. working with local HVAC contractors to offer renewable energy products to clients).
- *Next Generation Exercise Machines*: Sponsored by Curves International, this research was focused on improving the kinematics, electromechanical design and manufacturability of hydraulic resistance exercise equipment.
- *Swarm Intelligence*: Research into mathematical theories to describe how large numbers of agents executing simple rules can accomplish complex tasks. Work here uses dynamical system theory to show that aggregate behavior of simple swarms can be predicted from the given rules, even if individual agents’ behaviors are unpredictable.

## Refereed Journal and Transaction Publications

1. J. Davis, I. Gravagne, R.J. Marks, “[Convergence of Unilateral Laplace Transforms on Time Scales](#),” *Circuits, Systems and Signal Processing*, vol. 29, 2010, p. 971-997.
2. J. Davis, I. Gravagne, R.J. Marks, “[Bilateral Laplace Transforms of Time Scales: Convergence, Convolution, and the Characterization of Stationary Stochastic Time Series](#),” *Circuits, Systems and Signal Processing*, vol. 29, 2010, pp. 1141-1165.
3. Gravagne, J.M. Davis, J. DaCunha, “[A Unified Approach to High-Gain Adaptive Controllers](#),” *Journal of Abstract and Applied Analysis*, vol. 2009, article ID 198353.
4. B. Jackson, J. Davis, I. Gravagne, R.J. Marks, “[Controllability, Observability, Realizability, and Stability of Dynamic Linear Systems](#),” *Electronic Journal of Differential Equations (EJDE)*, vol. 2009, no. 37, pp. 1-32.

5. R.J. Marks, I. Gravagne, J. Davis, "[A Generalized Fourier Transform and Convolution on Time Scales](#)," J. Mathematical Analysis and Applications, vol. 340, no. 2, April 2008, pp. 901-919.
6. J. Davis, I. Gravagne, B.J. Jackson, R.J. Marks, A.A. Ramos, "The [Laplace Transform on Time Scales, Revisited](#)," J. Mathematical Analysis and Applications, vol. 322, 2007, pp. 1291-1307.
7. I. Gravagne, R.J. Marks, "[Emergent Behaviors of Protector, Refugee and Aggressor Swarms](#)," IEEE Trans. Systems Man and Cybernetics (B), vol. 37, no. 2, April 2007, pp. 471-477.
8. I. Gravagne, I.D. Walker and C.D. Rahn, "[Large-Deflection Dynamics and Control for Planar Continuum Robots](#)," IEEE/ASME Trans. Mechatronics, vol. 8, no. 2, June 2003, pp. 299-307.
9. R.J. Marks, I. Gravagne, J. Davis, J. DaCunha, "[Nonregressivity in Switched Linear Circuits and Mechanical Systems](#)," Mathematical and Computer Modeling, vol. 43, 2006, pp. 1383-1392.
10. I. Gravagne and I.D. Walker, "[Manipulability, Force, and Compliance Analysis for Planar Continuum Manipulators](#)," IEEE Trans. Robotics and Automation, vol. 18, no. 3, June 2002, pp. 263-273.
11. I. Gravagne and I.D. Walker, "[On the Structure of Minimum Effort Solutions with Application to Kinematic Redundancy Resolution](#)," IEEE Trans. Robotics and Automation, vol. 16, no. 6, December 2000, pp. 855-863.

### Conference Proceedings (refereed unless indicated by \*)

12. J.M. Davis, I. Gravagne, R.J. Marks, A. Ramos, "[Algebraic and Dynamic Lyapunov Equations on Time Scales](#)," Proc. 42<sup>nd</sup> South Eastern Symposium on System Theory, Tyler, TX, March 2010, paper T2A.2.
13. J.M. Davis, I. Gravagne, J.R. Marks, J. Miller, A. Ramos, "[Stability of Switched Linear Systems on Non-Uniform Time Domains](#)," Proc. 42<sup>nd</sup> South Eastern Symposium on System Theory, Tyler, TX, March 2010, paper M2B.5.
14. J.M. Davis, I. Gravagne, R.J. Marks, "[Time Scale Discrete Fourier Transforms](#)," Proc. 42<sup>nd</sup> South Eastern Symposium on System Theory, Tyler, TX, March 2010, paper T2B.1.
15. J.M. Davis, I. Gravagne, B. Jackson, R.J. Marks, "[State Feedback Stabilization of Linear Time-Varying Systems on Time Scales](#)," Proc. 42<sup>nd</sup> South Eastern Symposium on System Theory, Tyler, TX, March 2010, paper M1A.1.
16. K. Van Treuren, I. Gravagne, "An Engaged Learning Group for Energy Literacy at Baylor University," 2010 ASEE Gulf-Southwest Annual Conference, Lake Charles, LA.
17. K. Van Treuren, I. Gravagne, "Developing an Energy Literacy Curriculum for Incoming Freshman at Baylor University: Lessons Learned," 2010 ASEE Annual Conference & Exposition, Louisville, KY.
18. J. Gregg, J. Shane Merchant, K. Van Treuren, I. Gravagne, "Experimental Analysis of a Counter-Rotating Wind Turbine," Paper IMECE 2009-11355, Proceedings of the ASME 2009 International Mechanical Engineering Congress & Exposition, Lake Buena Vista, Florida, November 13-19, 2009. [*3<sup>rd</sup> place paper student paper award.*]
19. \*I. Gravagne, J. Davis, "[Mu-Dynamics on Time Scales: Adaptive Time Domains for Dynamical Systems](#)," NSF CMMI Engineering Research and Innovation Conference, Honolulu, HI, June 22-25, 2009.
20. J. Gregg, J. S. Merchant, K. Van Treuren, I. Gravagne, "Analysis of a Counter Rotating Wind Turbine," 2009 ASME Early Career Technical Conference, University of Texas, Arlington, April 17-18, 2009.
21. T. Cemo, K. Bolton, K. Van Treuren, I. Gravagne, "Design and Validation of a Solar Domestic Hot Water Heating Simulator," 2009 ASME Early Career Technical Conference, University of Texas, Arlington, April 17-18, 2009.
22. I. Gravagne, "[Engineering Mathematics for Graduate Students: To Teach or Not To Teach?](#)" 2009 ASEE Gulf-Southwest Conference, Waco, TX, March 2009, paper FB2-1.

23. J. S. Merchant, J. Gregg, K. Van Treuren, I. Gravagne, "[Wind Tunnel Analysis of a Counter-rotating Turbine](#)," ASEE Annual Gulf Southwest Conference, Baylor University, Waco, TX, March 18-20, 2009, paper TB3-1. [*1<sup>st</sup> place paper award, undergraduate students*]
24. K. Bolton, T. Cemo, I. Gravagne, K. Van Treuren, "[Design of a Solar Thermal Collector Simulator](#)," 2009 ASEE Gulf-Southwest Conference, Waco, TX, March 2009, paper TB4-1. [*2<sup>nd</sup> place paper award, graduate students*]
25. C. Matcek, J. Miller, I. Gravagne, "[Design of a Phantom Load Controller for Entertainment Centers](#)," 2009 ASEE Gulf-Southwest Conference, Waco, TX, March 2009, paper TC4-4. [*1<sup>st</sup> place paper award, graduate students*]
26. J. Miller, I. Gravagne, "[Stability of Simultaneously Triangularizable Switched Linear Systems on Time Scales](#)," ASEE Gulf-Southwest Conference, Waco, TX, March 2009, paper TB4-3.
27. K. Van Treuren, I. Gravagne, "[Energy Awareness Efforts at Baylor University](#)," Proc. ASEE Annual Conference & Exposition, Pittsburgh, PA, June 2008, paper AC 2008-1474.
28. I. Gravagne, K. Van Treuren, "[On the Use of TRNSYS in a Solar Energy Technical Elective](#)," Proc. ASEE Gulf Southwest Conference, Albuquerque, NM, March 2008, session 17, paper 4.
29. I. Gravagne, K. Van Treuren, "[Developing an Energy Literacy Curriculum at Baylor University](#)," Proc. ASEE Gulf Southwest Conference, Albuquerque, NM, March 2008, session 2, paper 1.
30. K. Van Treuren, I. Gravagne, "[Raising Community Energy Awareness: Building an Energy Display at the Mayborn Museum](#)," Proc. ASEE Gulf Southwest Conference, Albuquerque, NM, March 2008, session 16, paper 1.
31. I. Gravagne, J. Davis, R.J. Marks, "[How Deterministic Must a Real-Time Controller Be?](#)" Proc. IEEE/RSJ Int. Conf. on Intelligent Robots and Systems, Alberta, Canada, August 2005, pp. 3856-3861.
32. B. Levins, I. Gravagne, "[A Magnetically Controllable Valve to Vary the Resistance of Hydraulic Dampers for Exercise Machines](#)," Proc. IEEE/ASME Int. Conf. on Advanced Intelligent Mechatronics, Monterey, CA, July 2005, pp. 492-497.
33. I. Gravagne, J. Davis, J. Dacunha, R.J. Marks, "[Bandwidth Reductions for Controller Area Networks Using Adaptive Sampling](#)," Proc. IEEE Int. Conf. Robotics and Automation, New Orleans, LA, April 2004, pp. 5250-5255.
34. I. Gravagne, R. Woodfin, C. Schmidt, "[Now that I have a robot, what do I tell it to do?](#)" Proc. 6<sup>th</sup> Int. Symposium on Technology and the Mine Problem, Monterey, CA, May 2004.
35. I. Gravagne, "[Asymptotic Regulation of a One-Section Continuum Manipulator](#)," Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems, Las Vegas, NV, Oct. 2003, pp. 2779-2784.
36. I. Gravagne, C.D. Rahn and I.D. Walker, "[Uniform Control of Continuum Robot Manipulators](#)," Proc. IEEE Int. Conference on Robotics and Automation, Washington DC, May 2002, pp. 1519-1524.
37. I. Gravagne, R. Woodfin, "[Mine-Sniffing Robotics Snakes and Eels: Fantasy or Reality](#)," Prof. 5<sup>th</sup> Int. Symposium on Technology and the Mine Problem, Monterey, CA, April 2002.
38. I. Gravagne and I.D. Walker, "[Manipulability and Force Ellipsoids for Continuum Robot Manipulators](#)," Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems, Maui, Hawaii, October 2001, pp. 304-311.
39. I. Gravagne, C.D. Rahn, and I.D. Walker, "[Good Vibrations: A Vibration Damping Setpoint Controller for Continuum Robots](#)," Proc. IEEE Int. Conf. Robotics and Automation, Seoul, S. Korea, May 2001, pp. 3877-3883.
40. I. Gravagne and I.D. Walker, "[Kinematic Transformations for Remotely-Actuated Planar Continuum Robots](#)," Proc. of the IEEE Int. Conf. Robotics and Automation, San Francisco, CA, April 2000, pp. 19-26.
41. I. Gravagne and I.D. Walker, "[On the Kinematics of Remotely-Actuated Continuum Robots](#)," Proc. IEEE Int. Conf. Robotics and Automation, San Francisco, CA, April 2000, pp. 2544-2550.

42. I. Gravagne and I.D. Walker, "[Kinematics for Constrained Continuum Robots Using Wavelet Decomposition](#)," Robotics 2000, Proc. 4<sup>th</sup> Int. Conf. and Exposition/Demonstration on Robotics for Challenging Situations and Environments, Feb. 2000, pp. 292-298.
43. I. Gravagne and I.D. Walker, "[Avoiding Discontinuities while Using the Minimum Infinity Norm to Resolve Kinematic Redundancy](#)," Proc. IEEE/ASME Int. Conference Advanced Intelligent Mechatronics, Sep 1999, pp. 398-403.
44. A.M. Ramos, I.A. Gravagne, and I.D. Walker, "[Goldfinger: A Non-anthropomorphic, Dextrous Robot Hand](#)," Proc. Int. Conf. Robotics and Automation, Detroit, MI, May 1999, pp. 913-919.
45. I. Gravagne and I.D. Walker, "[Properties of Minimum Infinity-Norm Optimization Applied to Kinematically Redundant Robots](#)," Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems, Victoria, B.C., Canada, October 1998, pp. 152-160.

### **Non-Published Presentations**

46. "Lyapunov Stability of Non-Diagonalizable Switched Linear Systems on Time Scales," Abstract and Presentation with J. Miller, AMS regional meeting 1051, Baylor University, October 2009, abstract number 1051-93-216.
47. "How Stuff Works: RFID," Heart of Texas Amateur Radio Club (HOTARC), Texas State Technical College, Waco, TX, July 26, 2007.
48. "High-Gain Adaptive Control on Time Scales," invited speaker, special session on hybrid methods for differential equations, 7<sup>th</sup> Int. Conf. Computational & Math. Methods in Sci. and Eng., June 2007 .
49. "The Nuts and Bolts of RFID," invited speaker, RFID Integrated Supply Chains Conference, Baylor University, Hankamer School of Business, October 21, 2005.
50. "Emergent Behaviors of Bonabeau Swarming," Baylor Engineering and Research Seminar, Feb. 17, 2005.
51. "Applications of Time Scales to Real-Time Communication Networks," invited speaker, special session on Time Scale Applications, AMS Western Sectional, Univ. of S. California, Los Angeles, CA, April 3, 2004.
52. "Advances in Mathematical Modeling: Dynamic Equations on Time Scales," Baylor Engineering and Research Seminar, Nov. 20, 2003.
53. "Soft Robotics: New Frontiers in Dynamical Systems," invited speaker, Dept. of Mathematics, Baylor University, Jan. 29, 2003.
54. "Design, Analysis and Experimentation: the Fundamentals of Continuum Robotic Manipulators," Electrical and Mechanical Engineering Departments, Texas A&M University, Oct. 9, 2002.
55. "Next Generation Robotics: Trunks and Tentacles," Baylor School of Engineering and Computer Science, Sept. 11, 2002.