Professor William Singhose, PhD

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I. Earned Degrees
1997, Ph.D. Mechanical Engineering, Massachusetts Institute of Technology
1992, M.S. Mechanical Engineering, Stanford University
1990, B.S. Mechanical Engineering, Massachusetts Institute of Technology

II. Employment History
Georgia Institute of Technology (8/98 – present) Atlanta, GA
Professor of Mechanical Engineering (2014-Present). Associate Professor (2004-2014). Assistant Professor (1998-2004). Head of Automation and Mechatronics Group (2006-2010). Develop curriculum and teach courses in mechanical design, dynamics, controls, and rehabilitation engineering. Develop research programs and proposals. Direct research of graduate students, undergraduate students, and postdoctoral researchers in the areas of dynamics, vibration suppression, robotics, spacecraft, crane control, flight control, and active seating technology. Advise SME, ASME, and CanSat student groups. Held visiting appointments at MIT, Stanford, the Tokyo Institute of Technology, and Polytechnic University of Madrid.

InVekTek, Inc. (12/15 – present) Atlanta, GA
Co-Founder and CTO. Develop and commercialize control systems for robotic and industrial material-handling systems. The control systems are embedded in motor drives to reduce unwanted machine motion.

Google, Inc. (9/17 – 12/19) Mountain View, CA
Pennington Advisor mechanical engineer to Google's augmented reality (Daydream) and Advanced Technology and Projects (ATAP) facilities. Performed mechanical design and analysis of hand-held consumer electronic products and wearable devices. Performed failure and hazard analyses. Directed and performed research activities on human-motion measurement, human-machine interactions, actuation system design, and activity monitoring.

Stanford University (3/18 – 7/19) Stanford, CA
Visiting Professor in the Department of Mechanical Engineering. Delivered lectures on product design, safety analysis, and sensors. Advised student design teams.

CAMotion Cranes, Inc. (9/08 – 11/2013) Atlanta, GA
Co-Founder and Board Member. Developed and commercialized crane-control technology. Controllers improve crane safety, throughput, and ease of operation. Sold company to PaR Systems in Nov. 2013.

Massachusetts Institute of Technology (9/10 – 6/11) Cambridge, MA
Taught graduate-level controls course. Supervised research projects. Developed textbook on command-shaping control methods.

Polytechnic University of Madrid (5/10 – 8/10) Madrid, Spain

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Taught course in manufacturing controls. Supervised construction of experimental equipment. Developed international collaborative research projects.

Tokyo Institute of Technology (10/05 – 4/06) Tokyo, Japan
Visiting Associate Professor in Center of Excellence in Robotics. Taught advanced control course. Conducted experiments with robotic crane. Developed research proposals with Japanese collaborators.

Massachusetts Institute of Technology (6/97 – 7/98) Cambridge, MA
Postdoctoral Fellow in the NSF Center for Innovation in Product Development. Directed the development of an internet-controlled machine. Conducted research in design process optimization. Taught senior-level design course.

Convolve, Inc. (4/92 - 8/94) Armonk, NY
Managed NSF sponsored project investigating techniques for inspecting manufactured parts using measurement robots. Developed computer simulations of manufacturing robots, coordinate measuring machines, car seats, and NASA weather balloons. Designed control systems for automated machines. Designed data acquisition system using a laser interferometer.

Apple Computers, Inc. (6/91 - 3/92) Santa Clara, CA
Designed and performance evaluation tests for the Audio-Visual 14" Monitor. Designed and constructed test equipment. Organized, interpreted and reported test results produced by product evaluation team. Made design recommendations based on test results and dynamic simulations.

Walt Disney World (5/90-8/90) Orlando, FL
Designed components for the Space Mountain rehabilitation project. Performed failure analysis and developed design changes for Star Tours and Body Wars simulators Performed stress analysis of the Star Jets base plate and specified welds. Designed IR sensor mount and cable management for the Norway Pavilion water ride. Formulated repair procedures for Pirates of the Caribbean roller bearings.

Artificial Intelligence Laboratory (12/87 - 6/90) Cambridge, MA
Developed computer simulations of flexible robots. Performed research on command-shaping methods to eliminate vibration in computer controlled machines. Performed robotic experiments to verify controller's robustness to modeling errors and changing configurations. Verified new control theory by performing simulations of the space shuttle's robotic arm. The control methods were tested on-orbit in Space Shuttle Endeavour.

Cable News Network (Summer '89) Atlanta, GA
AAAS Mass Media Science and Engineering Fellow. Wrote several stories for CNN Science and Technology. Field producer on stories covering the Starship 1 aircraft and an international climate study. Produced a story reporting on a car seat that lowers impact forces during head-on collisions.

Riverside Cement Company (Summer '88) Riverside, CA
Cement lab technician. Designed and performed experiments to test mechanical properties of cement. Operated a wide range of equipment including forklifts, cement pumps, sand sifters, trucks, climatic test chambers, and compression testing machines.

Bill's Asphalt Repair (8/85-8/87) Springfield, OR
Developed bids and executed construction projects involving asphalt and concrete structures. Operated heavy machinery including: dump trucks, paving machines, steam rollers, and compactors.

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III. Honors and Awards

Academic

2015 Asian Control Conference, Best Application Paper Finalist
2013 Zeigler Woodruff School Outstanding Educator Award
2009 Georgia Tech SAIC Student Paper Contest Winner, Graduate Division
2006 Georgia Tech SAIC Student Paper Contest Winner, Undergraduate Division
2004 CETL Educational Partnership Award
2003 SME Jiri Tlusty Outstanding Young Manufacturing Engineer Award
2002 Georgia Tech SAIC Student Paper Contest Winner, Undergraduate Division
2002 CETL/BP Junior Faculty Teaching Excellence Award
2002 Japan Society for the Promotion of Science Invitation Fellowship
2001 Georgia Tech SAIC Student Paper Contest Winner, Undergraduate Division
1996 Massachusetts Space Grant Fellowship
1990 Office of Naval Research Fellowship
1990 Phi Beta Kappa
1989 AAAS Mass Media Science and Engineering Fellowship
1989 Tau Beta Pi
1989 Pi Tau Sigma

Academic and Athletic

1990 The GTE Academic All-American, Collegiate Division (only one award nationally each year)
1990 NCAA Postgraduate Scholarship
1990 NACDA/Walt Disney Scholar-Athlete Award

Athletic

1989 NCAA Division III National Decathlon Champion
1990 New England Division III Athlete of the Year
1990 All New England Field Athlete of the Year
1988-1990 NCAA Division III All-American (8-Times)

IV. Research, Scholarship, and Creative Activities

A. Published Books, Book Chapters, and Edited Volumes

[1] J. Vaughan and W. Singhose, "Advances in Delays and Dynamics at Springer," in *The Influence of Time Delay on Crane Operator Performance*. 2014

[2] W. Singhose, "Trajectory Planning for Flexible Robots," in *CRC Robotics and Automation Handbook*, T. Kurfess, Ed.: CRC Press, 2004.

[3] W. Singhose and W. Seering, "Control of Flexible Manipulators with Input Shaping Techniques," in *Flexible Robot Manipulators: Modelling, Simulation and Control*, M. O. Tokhi and A. K. M. Azad, Eds. Stevenage, UK: The Institution of Engineering and Technology, 2008, pp. 235-257.

[4] W. Singhose and J. Donnell, *Introductory Mechanical Design Tools*: www.lulu.com/content/3365814, 978-0-9842210-4-2, 2009.

[5] W. Singhose, J. Donnell, and D. Frakes, *Introductory Biomechanical Design Tools*: www.lulu.com/content/8235890, 978-0-9842210-5-9, 2010.

[6] W. Singhose and W. Seering, *Command Generation for Dynamic Systems*: www.lulu.com/content/621219, 978-0-9842210-0-4, 2010.

[7] M. A. Lau and W. E. Singhose, "Optimal Control of Dynamical Systems," in *Applications of Spreadsheets in Education The Amazing Power of a Simple Tool*, M. L. a. S. Sugden, Ed.: Bentham Science Publishers Ltd., 2011, pp. 41–63.

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[8] W. Singhose, J. Donnell, and Y. Hu, *Introductory Mechanical Design Tools (in Chinese)*. Wuhan, China: Huazhong University of Science and Technology Press, 978-7-5609-7926-7, 2012.

B. Refereed Publications and Submitted Articles

Journal Articles

[1] W. Singhose, W. Seering, and N. Singer, "Residual Vibration Reduction Using Vector Diagrams to Generate Shaped Inputs," *ASME J. of Mechanical Design,* vol. 116, no. June, pp. 654-659, 1994.

[2] W. Singhose, K. Bohlke, and W. Seering, "Fuel-Efficient Pulse Command Profiles for Flexible Spacecraft," *AIAA J. of Guidance, Control, and Dynamics,* vol. 19, no. 4, pp. 954-960, 1996.

[3] W. Singhose, S. Derezinski, and N. Singer, "Extra-Insensitive Input Shapers for Controlling Flexible Spacecraft," *AIAA J. of Guidance, Control, and Dynamics,* vol. 19, no. 2, pp. 385-91, 1996.

[4] W. Singhose and N. Singer, "Effects of Input Shaping on Two-Dimensional Trajectory Following," *IEEE Trans. on Robotics and Automation,* vol. 12, no. 6, pp. 881-887, 1996.

[5] W. Singhose, N. Singer, and W. Seering, "Improving Repeatability of Coordinate Measuring Machines with Shaped Command Signals," *Precision Engineering,* vol. 18, no. April, pp. 138-146, 1996.

[6] L. Y. Pao and W. E. Singhose, "Verifying Robust Time-Optimal Commands for Multi-Mode Flexible Spacecraft," *AIAA J. of Guidance, Control, and Dynamics,* vol. 20, no. 4, pp. 831-833, 1997.

[7] W. Singhose, A. Banerjee, and W. Seering, "Slewing Flexible Spacecraft with Deflection-Limiting Input Shaping," *AIAA J. of Guidance, Control, and Dynamics,* vol. 20, no. 2, pp. 291-298, 1997.

[8] W. Singhose and L. Pao, "A Comparison of Input Shaping and Time-Optimal Flexible-Body Control," *IFAC Control Engineering Practice,* vol. 5, no. 4, pp. 459-467, 1997.

[9] W. Singhose, L. J. Porter, T. D. Tuttle, and N. C. Singer, "Vibration Reduction Using Multi-Hump Input Shapers," *ASME J. Dynamic Systems, Measurement, and Control,* vol. 119, no. June, pp. 320-326, 1997.

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[13] A. K. Banerjee and W. E. Singhose, "Command Shaping in Tracking Control of a Two-Link Flexible Robot," *AIAA J. of Guidance, Control, and Dynamics,* vol. 21, no. 6, pp. 1012-1015, 1998.

[14] L. Y. Pao and W. E. Singhose, "Robust Minimum Time Control of Flexible Structures," *Automatica,* vol. 34, no. 2, pp. 229-236, 1998.

[15] N. C. Singer, W. E. Singhose, and W. P. Seering, "Comparison of Filtering Methods for Reducing Residual Vibration," *European Journal of Control,* vol. 5, no. 2, pp. 208-219, 1999.

[16] W. Singhose, B. Mills, and W. Seering, "Closed-Form Methods for Generating On-Off Commands for Undamped Flexible Structures," *AIAA J. of Guidance, Control, and Dynamics,* vol. 22, no. 2, pp. 378-82, 1999.

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[46] J. Danielson, J. Lawrence, and W. Singhose, "Command Shaping for Flexible Systems Subject to Constant Acceleration Limits," *ASME J. Dynamic Systems, Measurement, and Control,* vol. 130, no. 5, pp. 0510111-0510118, 2008.

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[52] Y.-G. Sung and W. Singhose, "Deflection-Limiting Commands for Systems with Velocity Limits," *AIAA J. of Guidance, Control, and Dynamics,* vol. 31, no. 3, pp. 472-8, 2008.
[53] J. Vaughan, J. Fortgang, W. Singhose, J. Donnell, and T. Kurfess, "Using Mechatronics to Teach Mechanical Design and Technical Communication," *Mechatronics,* vol. 18, no. 4, pp. 179-186, 2008.
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[346] W. Singhose, K. Peng, A. Garcia, and A. Ferri, "Dynamics and Control of Crane Payload Lift-off and Lay-down Operations," in *International Conference on Material Handling, Constructions and Logistics*, Vienna, Austria, 2015.
[347] Y. Hu, D. Han, L. Ling, T. Kurfess, W. Singhose, and J. Vaughan, "Case Study: Comparison of Project-based, Creative Engineering Courses at Georgia Tech and Huazhong University of Science and Technology," in *Int. Conf. on Engineering Education and Research*, Sydney, Australia, Nov. 21-24 2016.
[348] R. Khodambashi, G. Weinberg, W. Singhose, S. Rishmawi, V. Murali, and E. Kim, "User oriented assessment of vibration suppression by command shaping in a supernumerary wearable robotic arm," in *IEEE-RAS International Conference on Humanoid Robots*, Cancun, Mexico, Nov 15-17 2016.
[349] A. S. Miller, W. Singhose, and U. Glauser, "Integrating PLC Theory and Programming into Advanced Controls Courses," in *American Control Conference*, Boston, MA, 2016.
[350] A. Castro, W. Singhose, X. Liu, K. Sorensen, and E. C. Kwak, "Modeling and Experimental Testing of Hoverboard Dynamic Behavior," in *ASME Dynamic Systems and Control Conference*, Tysons Corner, Virginia, 2017.
[351] S. Grazioso, G. D. Gironimo, W. Singhose, and B. Siciliano, "Input Predictive Shaping for Vibration Control in Flexible Systems," in *IEEE Conference on Control Technology and Applications*, Kohala Coast, Hawai'i, USA, 2017.
[352] A. Kivila, J. Burgin, W. Book, and W. Singhose, "Development and Verification of a 2-Link Flexible Serial Arm Testbed for 3D Spatial Movements," in *IEEE 11th Asian Control Conference*, Gold Coast, Australia, 2017: IEEE.
[353] S. Rishmawi and W. Singhose, "Control of Robotic Crawler Cranes in Tandem Lifting Operations," in *Future Technologies Conference*, Vancouver, Canada, 2017.
[354] F. Schlagenhauf, P. P. Sahoo, and W. Singhose, "Comparison of Single-Kinect and Dual-Kinect Motion Capture of Upper-Body Joint Tracking," in *Asian Control Conference*, Gold Coast, Australia, 2017.

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[355] S. Ichikawa, A. Castro, N. Johnson, H. Kojima, and W. Singhose, "Dynamics and command shaping control of quadcopters carrying suspended loads," in *14th IFAC Workshop on Time Delay Systems TDS (IFAC-PapersOnLine)*, Budapest, Hungary, 2018, vol. 51, no. 14, pp. 84 - 88.

[356] N. Johnson and W. Singhose, "Dynamics and Modeling of a Quadrotor with a Suspended Payload " in *AIAA Aviation Forum Applied Aerodynamics Conference*, Atlanta, GA, 2018.

[357] P. P. Sahoo and W. Singhose, "Effects of Input Shaping on Impact Loads During Collisions Involving Flexible Robots," in *IEEE Int. Conf. on Control and Automation*, Anchorage, Alaska, 2018.

[358] F. Schlagenhauf and W. Singhose, "Comparison of Sway Reduction Controllers for Construction Cranes," in *IEEE Int. Conf. on Control and Automation*, Anchorage, Alaska, 2018.

[359] F. Schlagenhauf, S. Sreeram, and W. Singhose, "Comparison of Kinect and Vicon Motion Capture of Upper-Body Joint Angle Tracking," in *IEEE Int. Conf. on Control and Automation*, Anchorage, Alaska, 2018.

[360] K. Sorensen and W. Singhose, "Wheeled Inverted Pendulum Control and Slip Dynamics," in *IEEE Int. Conf. on Control and Automation*, Anchorage, Alaska, 2018.

[361] W. S. W. S. D. Frakes, "Soli Radar Image-Based Target Localization," in *IEEE Int. Conf. on Image Processing*, Bordeaux, France, 2022.

[362] T. Rome, W. S. K. D. K. Sorensen, F. Schlagenhauf, and J.-W. Kang, "Impact of Input Shaper Discretization on Linear Resonant Actuators for Haptic Feedback," in *IEEE International Symposium on Industrial Electronics*, Anchorage, AK, 2022.

[363] C. Adams and W. Singhose, "Stability Margins of Heavy-Lifting Machines with a Telescoping Boom and Jib," in *Submitted to the 2023 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)*, Seattle, WA.

[364] A. Jenkins, D. V. Delden, and W. Singhose, "Controlling Human Perception of Haptic Profiles Using Contextual Cues," in *Submitted to IEEE World Haptics 2023 conference*, Delft, Netherlands.

[365] A. Jenkins, D. V. Delden, and W. Singhose, "Controlling Physical Reactions to Wrist-Based Haptics," in *Submitted to IEEE World Haptics 2023 conference*, Delft, Netherlands.

[366] A. Jenkins, D. V. Delden, W. Singhose, and K. Sorensen, "Recent Studies Applicable to Creating Haptic Sensations in Wearable Devices," in *Submitted to IEEE World Haptics 2023 conference*, Delft, Netherlands.

[367] M. W. Lui, D. Kotten, E. Dushaj, and W. Singhose, "Improving Human Positioning Control of Oscillatory Systems," in *Submitted to the 2023 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)*, Seattle, WA.

[368] T. Rome, C. Adams, and W. Singhose, "Experimental Comparison of Manual and Automated Crane Control Through Obstacle Field," in *Submitted to the 2023 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM)*, Seattle, WA.

C. Other Publications and Creative Products

Invited papers

[369] W. Singhose, "Shaping Inputs to Reduce Vibration: A Vector Diagram Approach," MIT Artificial Intelligence Lab Memo No. 1223, March 1990. [Online]. Available: invited

[370] W. Singhose and W. Seering, "Generating Vibration-Reducing Inputs with Vector Diagrams," in *IFToMM Eighth World Congress on the Theory of Machines and Mechanisms*, Prague,

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Czechoslovakia, 1991, vol. 1, pp. 315-318. [Online]. Available: invited. [Online]. Available: invited

[371] A. K. Banerjee and W. E. Singhose, "Slewing and Vibration Control of a Nonlinearly Elastic Shuttle Antenna," in *AIAA/AAS Astrodynamics Specialists Conf.*, Scottsdale, AZ, 1994. [Online]. Available: invited. [Online]. Available: invited

[372] W. Singhose and N. Singer, "Initial Investigations into the Effects of Input Shaping on Trajectory Following," in *American Control Conference*, Baltimore, MD, 1994, vol. 3, pp. 2526-32. [Online]. Available: invited. [Online]. Available: invited

[373] W. E. Singhose and N. C. Singer, "Improving Coordinate Measuring Machine Repeatability with Input Shaping," in *NSF Design and Manufacturing Grantees Conf.*, Cambridge, MA, 1994, pp. 467-8. [Online]. Available: invited. [Online]. Available: invited

[374] A. K. Banerjee and W. E. Singhose, "Minimum Time Fuel Efficient Maneuver of Flexible Spacecraft with Vibration Amplitude Constraint," in *AAS Astrodynamics Specialist Conf.*, Halifax, Nova Scotia, 1995, vol. AAS 95-318. [Online]. Available: invited. [Online]. Available: invited

[375] W. Singhose and T. Chuang, "Reducing Deviations From Trajectory Components With Input Shaping," in *American Control Conference*, Seattle, WA, 1995, vol. 1, pp. 929-33. [Online]. Available: invited. [Online]. Available: invited

[376] W. Singhose, W. Seering, and N. Singer, "The Effect of Input Shaping on Coordinate Measuring Machine Repeatability," in *IFToMM Ninth World Congress on the Theory of Machines and Mechanisms*, Milan, Italy, 1995, vol. 4, pp. 2930-2934. [Online]. Available: invited. [Online]. Available: invited

[377] W. Singhose, N. Singer, and W. Seering, "Comparison of Command Shaping Methods For Reducing Residual Vibration," in *Third European Control Conf.*, Rome, Italy, 1995, vol. 2, pp. 1126-1131.

[378] N. Singer, L. Pao, W. Singhose, and W. Seering, "An Efficient Algorithm for the Generation of Multi-Mode Input Shaping Sequences," in *IEEE Int. Conf. on Control Applications*, Dearborn, MI, 1996. [Online]. Available: invited. [Online]. Available: invited

[379] W. E. Singhose, W. P. Seering, and A. Banerjee, "An Evaluation of Fuel-Efficient On-Off Input Shaping with Deflection Limiting," in *AIAA/AAS Astrodynamics Specialist Conf.*, San Diego, CA, 1996. [Online]. Available: invited. [Online]. Available: invited

[380] A. K. Banerjee and W. E. Singhose, "Command Shaping in Tracking Control of a Two-Link Flexible Manipulator," in *AIAA Astrodynamics Conf.*, Sun Valley, ID, 1997, vol. AAS 97-721. [Online]. Available: invited. [Online]. Available: invited

[381] H. J. S. Feder, W. E. Singhose, and W. P. Seering, "Input Shaping for Collision Avoidance with Robotic Manipulation of Suspended Payloads," in *11th Symposium on Structural Dynamics and Control*, Blacksburg, VA, 1997. [Online]. Available: invited. [Online]. Available: invited

[382] N. Singer, W. Singhose, and E. Kriikku, "An Input Shaping Controller Enabling Cranes to Move Without Sway," in *ANS 7th Topical Meeting on Robotics and Remote Systems*, Augusta, GA, 1997, vol. 1, pp. 225-231. [Online]. Available: invited. [Online]. Available: invited

[383] W. Singhose, I. Villanueva, and W. Seering, "Use of Neural Networks for Generation of On-Off Commands for Flexible Systems," in *12th IEEE Int. Symp. on Intelligent Control*, Istanbul, Turkey, 1997.

[384] B. W. Mills, W. E. Singhose, and W. P. Seering, "Closed-Form Generation of Specified-Fuel Commands for Flexible Systems," in *American Control Conference*, Philadelphia, PA, 1998, vol. 5: IEEE, Piscataway, NJ, pp. 2632-6.

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[385] A. Banerjee and W. Singhose, "Vibration Reduction for Flexible Spacecraft Following Momentum Dumping with/without Slewing," in *AAS/AIAA Astrodynamics Specialist Conference*, Girdwood, AK, 1999. [Online]. Available: invited. [Online]. Available: invited

[386] L. French, W. Singhose, and W. Seering, "An Expert System for the Design of Input Shapers," in *IEEE Conference on Control Applications*, Kohala, Hawaii, 1999. [Online]. Available: invited. [Online]. Available: invited

[387] K. Grosser and W. Singhose, "Command Generation for Flexible Telerobotic Arms," in *International Symposium on Motion and Vibration Control in Mechatronics*, Tokyo, Japan, 1999. [Online]. Available: invited. [Online]. Available: invited

[388] E. Ooten and W. Singhose, "Time-Optimal Commands for Sequential Motions of Flexible Systems with Numerator Dynamics," in *International Symposium on Motion and Vibration Control in Mechatronics*, Tokyo, Japan, 1999. [Online]. Available: invited. [Online]. Available: invited

[389] M. Robertson and W. Singhose, "Initial Guess Schemes for Generating Deflection-Limiting Commands," in *AAS/AIAA Astrodynamics Specialist Conference*, Girdwood, AK, 1999. [Online]. Available: invited. [Online]. Available: invited

[390] K. Grosser, J. Fortgang, and W. Singhose, "Limiting High Mode Vibration and Rise Time in Flexible Telerobotic Arms," in *Conf. on Systemics, Cybernetics, and Informatics*, Orlando, FL, 2000.

[391] M. Kenison and W. Singhose, "Concurrent Design of Input Shaping and Feedback Control for Insensitivity to Parameter Variations," in *Sixth Int. Workshop on Advanced Motion Control*, Nagoya, Japan, 2000. [Online]. Available: invited. [Online]. Available: invited

[392] E. Ooten and W. Singhose, "Command Generation with Sliding Mode Control for Flexible Systems," in *Sixth International Workshop on Advanced Motion Control*, Nagoya, Japan, 2000. [Online]. Available: invited. [Online]. Available: invited

[393] D. Frakes and W. Singhose, "Geometrically Constrained Optical-flow Based Tracking for the Extraction of Kinematic Data from Video," in *Fifth Int. Symp. on Computer Methods in Biomechanics and Biomedical Engineering*, Rome, Italy, 2001.

[394] E. Ooten-Biediger and W. Singhose, "Command Generation for Trajectory Planning of Coordinating Satellites," in *University Space Systems Symposium*, Honolulu, HI, 2002.

[395] M. Robertson and W. Singhose, "Deflection-Limiting Control of Flexible Spacecraft Using On-Off Thrusters," in *University Space Systems Symposium*, Honolulu, HI, 2002.

[396] E. Biediger and W. Singhose, "Formation Flying Satellite Control Utilizing Input Shaping," in *AIAA/AAS Astrodynamics Specialist Conf.*, Big Sky, Montana, 2003.

[397] E. Biediger, W. Singhose, D. Frakes, M. Kashiwa, and S. Matunaga, "An Investigation of Video Tracking on a Formation Flying Satellite Testbed," in *AIAA/AAS Astrodynamics Specialist Conf.*, Big Sky, Montana, 2003.

[398] W. Singhose, M. Robertson, T. Watanabe, H. Kojima, and A. Banerjee, "Tether-Based Actuators for Space Applications," in *2003 International Workshop on Advanced Sensors, Structural Health Monitoring, and Smart Structures*, Yokohama, Japan, 2003.

[399] T. Watanabe, T. Makida, H. A. Fujii, H. Kojima, and W. Singhose, "An Application of Input Shaping for Electrodynamic Tether System," in *AIAA/AAS Astrodynamics Specialist Conference*, Providence, Rhode Island, 2004.

[400] A. Banerjee, W. Singhose, and D. Blackburn, "Orbit Boosting of an Electrodynamic Tethered Satellite with Input-Shaped Current," in *AAS/AIAA Astrodynamics Specialist Conference*, Lake Tahoe, CA, 2005.

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[401] W. Singhose and D. Kim, "Robustness of Command-Shaping Control on Flexible Systems," in *Spring Research Conference on Statistics in Industry and Technology*, Chicago, IL, 2011.

D. Presentations

Keynote and Plenary Lectures

6/8/23 "Hazard Analysis of Mobile Juvenile Products," International Forum on Automotive and Mechanical Engineering (MECHFORUM2023)
9/23/15 "Dynamics and Control of Crane Payload Lift-off and Lay-Down Operations," XXI Triennial Int. Conference on Material Handling, Constructions, and Logistics, Vienna, Austria
10/27/14 "Using Mechatronics to Improve Human Operation of Complex Dynamic Systems," International Conference on Mechanics and Control Engineering, Asheville, NC
10/18/12 "Improving Human Operation of Oscillatory Dynamic Systems," International Conference on Control, Automation and Systems, Jeju, South Korea
10/19/06 "Crane Oscillation Control: Applications and Educational Uses," International Conference on Material Handling, Constructions, and Logistics, Belgrade, Serbia

Other Invited Lectures

3/2/20 "Legal Considerations of Sensor use in Emerging Technology," Google, Mountain View, CA
4/24/19 "Ethical Considerations of Sensor Use," Stanford University, Palo Alto, CA
11/29/18 "Killer Robots: Why You Will not be Owning a Self-Driving Car," Stanford University, CA
10/12/18 "Georgia Tech ARLISS Team", University of Oregon, Eugene, OR
2/26/18 "Command Generation for Flexible Systems," University of California, Berkeley, Berkeley, CA
10/3/16 "Oscillation Control Using Input Shaping Technology," Hankyong University, Anseong, South Korea
9/29/16 "Input Shaping Control Technologies", Shanghai Jiao Tong University, Shanghai, China
4/21/16 "Improving Manufacturing Machines with Command Shaping," Mercedes Manufacturing Facilities, Vance, AL
1/25/16 "Commercialization of University-Developed Technology," University of Chicago Booth School of Business, Chicago, IL
9/25/15 "Applications of Input Shaping Control Methods," Czech Technical University, Prague, Czech Republic
3/25/15 "Oscillation Control of Suspended Loads Using Command Shaping," Boeing BR&T – Vertical Lift, Mesa, AZ
1/22/15 "Building a Culture of Active Learning in Mechatronics," Kumoh National Institute of Technology, Gumi, South Korea
1/19-1/23/15 "Special Lectures on Mechatronics by Foreign Distinguished Professor," Kumoh National Institute of Technology, Gumi, South Korea
9/26/14 "Building a Culture of Active Learning", Georgia Tech Zeigler Lecture
8/4/14 "NI myRIO Design Real Systems, Fast: 2014 Student Project Success", Panelist, NI Week, Austin, TX
3/19/14 "Input Shaping for Oscillation Reduction in the Digital World", Auburn University
11/16/13 "Improving Machine Motion with Command Shaping", Wuxi Zhong Ding Logistics, Wuxi, China
11/14/13 "Improving Manufacturing Machines with Command Shaping", HUST-Wuxi Research Institute, Wuxi, China
11/13/13 "Analyzing Accident Videos of Inverted-Pendulum Human Transporters", Huazhong University of Science and Technology, Wuhan, China

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4/15/13 “Control of Large Flexible Spacecraft, Robots, and Cranes”, Budapest University of Technology and Economics, Budapest, Hungary
4/15/13 “Recue Robot: An International Student Design Collaboration”, University of Patras, Patras, Greece
10/17/12 “Active Learning Methods for Mechanical Engineering”, Yeungnam College, Daegu, South Korea
6/26/12 “Command-Shaping Control of Flexible Aerospace Systems”, Beijing Institute of Technology Beijing, China
6/18-21/12 “Introductory Creative Decision and Design Tools for Mechatronics”, Huazhong University of Science and Technology, Wuhan, China
11/8/11 “Advanced Crane Control to Improve Safety and Ergonomics”, Boeing Research and Technology Ergonomics Road Show, Everett, WA
5/6/11 “Creative Decisions and Design: An Innovative Design Course at Georgia Tech”, Aalto University, Helsinki, Finland
4/25/11 “Creative Decisions and Design: An Innovative Design Course at Georgia Tech”, Chosun University, Gwangju, Korea
4/21/11 “Controlling Large Flexible Structures with Command Shaping”, Konkuk Univertsity, Seoul, Korea
4/19/11 “Command Shaping Control of Large Flexible Structures”, Shanghai Maritime University, Shanghai, China
4/18/11 “Creative Decisions and Design: An Innovative Design Course at Georgia Tech”, Huazhong University of Science and Technology, Wuhan, China
4/18/11 “Controlling Large Flexible Structures with Command Shaping”, Huazhong University of Science and Technology, Wuhan, China
4/1/11 “Command Shaping Control of Large Flexible Systems”, University of Parma, Parma, Italy
7/12/10 “Command Shaping Control of Large Flexible Systems”, University Carlos III, Madrid, Spain
6/18/10 “Advanced Crane Control Lab at Georgia Tech”, KoneCranes, Hyvinkää, Finland
5/3/10 “Command Shaping Control of Flexible Systems”, University Castilla-La Mancha, Ciudad Real, Spain
12/16/09 “Control of Cranes and Spacecraft using Command Shaping”, University of Sydney, Sydney, Australia

11/25/09 “The ASU Experience: Interfacing with the Machines“, Arizona State University, Tempe, AZ

11/25/09 “Interfaces and Control Systems for Intuitive Crane Control”, Arizona State University, Tempe, AZ

10/6/09 “Using Competitions in Mechatronics Engineering Education at Georgia Tech”, Chosun University, Kwangju, Korea

4/20/09 “Advanced Command Shaping Control of Cranes, Robots, and Spacecraft”, Instituto Automatique de Industriales, Madrid, Spain

11/25/08 “Command Shaping Control of Cranes, Robots, and Spacecraft”, Kyung Hee University, Suwon, Korea.

11/24/08 “Command Shaping Control of Cranes, Robots, and Spacecraft”, Seoul National University, Seoul, Korea.

11/21/08 “Command Shaping Control of Cranes, Robots, and Spacecraft”, Korean Atomic Energy Research Institute, Deajon, Korea.

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11/20/08 “Control of Tip-Over Instability”, Kumoh National Institute of Technology, Gumi, Korea.

8/10/08 “Engineering Teaching Methods at Georgia Tech”, Shandong Jianzhu University, Jinan, China.

8/10/08 “Using Command Shaping to Control Robots, Spacecraft, and Cranes”, Shandong Jianzhu University, Jinan, China.

8/8/08 “Control of Robots, Spacecraft, and Cranes Using Command Shaping”, Northeastern Forest University, Harbin, China.

8/7/08 “Engineering Teaching Methods at Georgia Tech”, Northeastern Forest University, Harbin, China.

8/4/08-8/8/08 “Command Shaping for Dynamic Systems”, Harbin Institute of Technology, Harbin, China.

5/28/07, “A Design Course at Georgia Tech: Creative Decisions & Design”, Center of Excellence in Robotics, Kumoh National Institute of Technology, Gumi, Korea.

5/24/07, “Making Robots and Cranes Move Very Fast with Command Shaping”, Northwest Forest University, Harbin, China.

5/23/07, “Making Robots and Cranes Move Very Fast with Command Shaping”, Harbin Institute of Technology, Harbin, China.

3/19/07, “Crane Dynamics and Control: Applications and Educational Uses”, Center of Excellence in Robotics, Tokyo Tech, Tokyo, Japan.

9/1/2006, “Crane Oscillation Control by Command Shaping”, Ishikawajima Harima Heavy Industries, Yokohama, Japan.

4/20/06, “High-Speed Motion Control Using Command Shaping”, Toshiba Corporate Research & Development Center, Tokyo, Japan.

1/25/2006, “”Command Shaping for Cranes and Other Flexible Systems”, University of Tokyo, Tokyo, Japan.

1/18/06, “Research Topics for Gantry Robots”, Kumoh National Institute of Technology, Gumi, South Korea.

12/13/05, “An Introduction to Command Shaping for Flexible Systems”, Center of Excellence in Robotics, Tokyo Tech, Tokyo, Japan.

8/12/05, “Advanced Command Shaping for Nonlinear Systems and On-Off Actuators”, Kumoh National Institute of Technology, Gumi, South Korea.

8/11/05, “An Introduction to Command Shaping for Flexible Systems”, Kumoh National Institute of Technology, Gumi, South Korea.

8/10/05, “An Introduction to Command Shaping for Flexible Systems”, Korea Institute of Machinery & Materials, Deajon, South Korea.

8/9/05, “Command Shaping for Flexible Systems”, Pusan National University, Busan, South Korea.

11/29/04, “Improving Machine Speed and Accuracy by Command Shaping”, Metz, France.

10/27/04 – “Improving the Speed of Cranes, Robots, and Micro Mills by Command Shaping”, Instituto Automatique de Industriales, Madrid, Spain

4/15/04 – “Undergraduate Research in Mechanical Engineering”, Meeting of Congressional Staffers, Georgia Tech Conference Center, Atlanta, GA.

3/10/04 – “Design of Physical Mechanisms to Reduce Unwanted Dynamics”, Nihon University, Tokyo, Japan.

1/29/04 – "Georgia Tech CanSat Team", Southeastern Space Grant Consortia Director’s Meeting, Atlanta, GA.

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10/23/03 - "Control of Flexible Spacecraft Using Command Shaping ", Georgia Tech IEEE meeting Atlanta, GA.
8/7/02 - "Rapid Motion of Crane-Like Structures", Tsukuba University, Tsukuba, Japan.
10/15/02 - "Designing Commands to Reduce Vibration in Mechanical Systems", ETSII de Madrid, Madrid, Spain.
10/14/02 - "Designing Commands to Reduce Vibration in Mechanical Systems", University of Vigo, Vigo, Spain.
8/13/02 - "Command Shaping for Flexible Structures", Tokyo Metropolitan Institute of Technology, Tokyo, Japan.
7/29/02 - "Controlling Flexible Spacecraft through Command Shaping", ISAS Astrodynamics Symposium Invited Speaker, Sagamihara, Japan.
7/13/02- "Using Input Shaping with On/Off Actuators", Laboratory for Space Systems, Tokyo Institute of Technology, Tokyo, Japan.
7/6/02- "Tutorial on Input Shaping for Moving Flexible Structures", Laboratory for Space Systems, Tokyo Institute of Technology, Tokyo, Japan.
3/18/02 - "Command Shaping Overview and Application to Hard Disk Drive Servo Control", Hitachi Corporation, Odawara, Japan.
3/15/02 - "Command Shaping for Vibration Reduction: Overview and Application to Hard Disk Drive Servo Control", IEE Committee Meeting for Mass Storage Servo, Nagoya, Japan.
10/27/00 - "Robotics Research at Georgia Tech." Waseda University, Tokyo, Japan.
10/24/00 - "Robotics Research at Georgia Tech." Tokyo Institute of Technology, Tokyo, Japan.
10/23/00 - "Robotics Research at Georgia Tech." Kyushu University, Fukuoka, Japan.
10/16/00 - "How to Properly Motivate Robots." MIT Club of Atlanta, Georgia Tech.
2/27/99 - "Making Machines Move Very Fast With Command Generation." American University in Cairo, Cairo, Egypt.

E. Grants and Contracts
A. As PI or Co-PI
Government Sources

"Input Shaping Mobile Crane Controllers", Georgia Research Alliance, October 2018, $49,965.

"I-Corps: Reducing Oscillation of Systems Driven by Stepper Motors and On-Off Actuators", National Science Foundation, April 2016, $50,000.

"Rocket Rescue Robot", Georgia Space Grant Consortium, August 2014, $6,000.

"Designing a Rocket-Launched Target-Seeking Rescue Robot", Georgia Space Grant Consortium, May 2013, $3,762.

"Hopping Rotochute Micro Satellite Design Project", Georgia Space Grant Consortium, July 2012, $2,275.

"International DDEP: Control of Complex Tower Crane Motion Using Low-Cost Cameras", National Science Foundation, September 2011-December 2012, $13,930.

"Input Shaping for Rotorcraft Sling Load Operation", National Rotorcraft Technology Center (NRTC), Jan. 2011 – May 2013, $120,000. **Co-PI (Singhose: $56,875)**

"Georgia Tech Student CanSat Team", Georgia Space Grant Consortium, Jan. 2006 - May 2010, $19,708.

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"International DDEP: Development of Aircraft Conflict Resolution Algorithms", National Science Foundation, May 2008-September 2008, $9,950.

"Approaches to Traffic Flow Management in the Presence of Uncertainty", NASA, October 2006-September 2008, $706,366. **Co-PI (Singhose: $120,056)**

"International DDEP: Experimental Evaluation of a Mobile Tower Crane", National Science Foundation, November 2006-March 2007, $10,800.

"International DDEP: Experimental and Educational Research with Remotely Operated Cranes", National Science Foundation, December 2005-March 2006, $8,100.

"Planning Visit: Large Flexible Space Structures", National Science Foundation, December 2005, $12,412.

"Application of Command Generation Techniques to the Control of Space Tether Systems", NASA/Marshall Space Flight Center, July 2005-July 2006, $24,000.

"Ph.D. Dissertation Enhancement Project: Experimental Evaluation of Low-Contact-Force Machining", National Science Foundation, January 2004-May 2004, $9,700.

Support for International Workshop on Advanced Sensors, Structural Health Monitoring, and Smart Structures, Yokohama, Japan, National Science Foundation, November 2003, $1,334.

"Command Generation and Control of Momentum Exchange Electrodynamic Reboost Tethered Satellite", NASA/Marshall Space Flight Center, August 2003-July2005, $48,000.

"Georgia Tech CanSat Development", Georgia Space Grant Consortium, December 2002 - December 2005, $20,851.

"Experimental Evaluation of Coordinated Flexible Satellite Control", National Science Foundation, November 2002, $7,995.

"Trajectory Planning for Coordinating Satellites Using Command Generation", NASA/ Goddard Space Flight Center, August 2002-July 2005, $72,000.

Industry Sources

"Evolution of Novel Haptic Actuation, Implementation and Test Systems" Google Inc., Jan. 2022, $249,869.

"Steady Hoist Swing-Damping Control for Rotocraft Operations," Atlas Devices Inc., March, 2021, $100,000.

"Development of Advanced Haptic Actuation Structures and Control Methods," Google Inc., Jan. 2021, $246,042.

"Development of Novel Haptic Actuation," Google Inc., Jan. 2020, $258,488.

"Dynamic Model and Control System Design for Cable-Driven Crane," ConcertLab, Jan. 2020, $27,088.

"Steady Hoist for Rotocraft Operations," Atlas Devices, LLC, Dec. 2019, $10,000.

"Mobile Vision GT Singhose SOW 5", Google Inc., Nov, 2017, $105,650.

"Mobile Vision GT Singhose SOW 4", Google Inc., Jan, 2017, $95,922.

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"Development Kits and myRIO Controllers for Undergraduate Controls", National Instruments, October 2016, $8,814.

"Mobile Vision GT Singhose SOW 3", Google Inc., August, 2016, $80,193.

"Mobile Vision GT Singhose SOW 2", Google, Inc. Jan, 2016, $112,309.

"Automated Large-Area Sanding", Boeing Research and Technology, Jan, 2016, $50,000.

"Mobile Vision - Design and Evaluation of a Mobile Vision-Based Device for Interactive Writing", Google Inc., June, 2015, $79,794.

"Automated Large-Area Painting", Boeing Research and Technology, May, 2015, $50,000.

"Hardware Integration for Large-Area Sensing", Boeing Research and Technology, July, 2014, $141,632.

"ME6404 Pneumatics project", National Fluid Power Association, November 2014, $4,520.

"PLC Programming Curriculum for Georgia Tech", Siemens, August 2014, $27,500.

"Use of Pneumatic Systems in Introductory Mechanical Design Projects", National Fluid Power Association, November 2013, $4,720.

"Development of Mechatronics and Robotics Educational Platforms Using Compact Control Units", National Instruments, May 2013, $117,000.

"Integration of Zurich University of Applied Sciences Bridge Crane into Georgia Tech Research and Educational Activities", Siemens, May 2013, $15,920.

"Manufacturing Technologies for the 21st Century", Boeing Research and Technology, Jan. 2013, $185,700.

"Multi-National Collaborative Design of Target-Seeking Robots", Boeing Research and Technology, Nov. 2012, $60,864.

"Multi-National Collaborative Design Tools", Boeing Research and Technology, Nov. 2012, $62,711.

"Input Shaping Analysis and Design Support", Space Systems Loral, August 2012, $47,086.

"Material Handling Dynamic Load Oscillation Suppression", Boeing Research and Technology, Jan. 2012, $100,000.

"Material Handling Dynamic Load Oscillation Suppression", Boeing Research and Technology, Jan. 2011, $100,000.

"A Balloon Hoist Experimental Setup to Evaluate National Instruments Products", National Instruments, March 2011, $38,665.

"Design & Development of a Pediatric Personal Transporter for Children with Disabilities", International Diversified Products, December 2010, $5,500. **Co-PI (Singhose: $2,750)**

"Siemens Automation – Cherrypicker Crane Project", Siemens Industry, August 2010, $44,732.

"Investigation of Commercial Personal Transporters", International Diversified Products, June 2010, $6,000. **Co-PI (Singhose: $3,000)**

"Material Handling Dynamic Load Oscillation Suppression", Boeing Research and Technology, Jan. 2010, $100,000.

Amazon Ex. 1004.0034

"Sponsorship of Georgia Tech Curriculum Improvements", British Petroleum, Nov. 2009, $7,500.

"Development of a Cherrypicker Aerial Lift for Use in Local and Remote Laboratories", Siemens Energy and Automation, Sept. 2009, $38,000.

"**Pneumatic Powered Advertisement Dispenser",** Diastone Corporation, May 2009, $8,800.

"Material Handling Dynamic Load Oscillation Suppression", Boeing Research and Technology, Jan. 2009, $100,000.

"Integrating Pneumatics Into Introductory Mechanical Design", National Fluid Power Association, May 2008, $4,960.

"Material Handling Dynamic Load Oscillation Suppression", Boeing Research and Technology, Jan. 2008, $75,000.

"Expansion of Pneumatic Systems in ME2110: Creative Decisions and Design", National Fluid Power Association, March 2006, $4,000.

"Pneumatic Equipment and Supplies for ME2110: Creative Decisions and Design", Festo Corporation, March. 2005, $6,898.

"Introduction of Pneumatic Systems into ME2110: Creative Decisions and Design", National Fluid Power Association, Nov. 2004, $5,000.

"Feedback and Command Shaping Control of Bridge Cranes", CAMotion, Inc. Jan. 2004 - August 2008, $98,168.

"Prototype Controller for Elastic Spacecraft", Northrop Grumman, January 2004 – December 2004, $44,415.

Support for University Space System Symposium, Jet Propulsion Laboratory, November 2002-5, $5,528.

"Control of Sloshing Liquid Demonstration Unit", National Instruments, March 2001, $1,500.

International Sources

"International Design and Construction of Quadrotors", Kumoh National Institute of Technology, December 2015, $6,000.

"International Cooperative Education in Engineering Design", Chosun University, November 2013, $9,000.

"Development of Educational Tasks in an Introductory Design Course", Chosun University, November 2011, $9,600.

"Development of a Mobile Mechatronic Device", Chosun University, June 2011, $9,600.

"Development of Educational Tasks in an Introductory Design Course", Chosun University, November 2010, $2,400.

"Research on Mobile Mechatronics Machine", Chosun University, November 2010, $3,600.

"Mechanical Manipulators Control, Education and Research", Ministerio de Ciencia e Innovacion de España, Dec. 2009, 18,000 Euro ($25,767).

"Environmentally-Friendly Automotive Parts - Human Resources Development Center", Chosun University, Dec. 2009, $6,000.

Amazon Ex. 1004.0035

"Versatile Command Shaping Controllers for Industrial Cranes", Kumoh National Institute of Technology, June 2006, $50,829

"Development of Vibration Reduction Scheme for XY Stages Using Input Shaping", Top Engineering Co., Center for Nano and Precision Technology, Kumi, Korea, December 2005, $5,000.

"Command Generation for Flexible Systems", Kumoh National Institute of Technology and Pusan National University, August 2005, 3300000 Won ($3,210).

"Enhanced Trajectory Tracking of Flexible Systems Using Command Generation", Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT), and Tokyo Metropolitan Institute of Technology (TMIT), $11,500 **Co-PI (Singhose: $5,750)**.

"Generación De Órdenes De Movimiento Que No Inducen Vibración En Maquinas Con FaltaDe Rigidez", University of Vigo, October 2002, 900 Euros.

"Experimental Investigation of Deflection-Limiting Satellite Thruster Control for Multiple Flexible Satellites", Japan Society for the Promotion of Science, June 2002, $17,245.

Internal Sources

"An International Collaborative Student Space Robot Design Initiative", Denning Global Engagement Seed Fund, 2014, $15,000.

GTRC travel grant to Serbia, July, 2014, $1,458.

"Interactive Tablet Computers for Introductory Mechanical Design", Georgia Tech Technology Fee Grant, 2013, $22,896.

"Power Analyzer for Energy-Efficient Student Design Projects", Georgia Tech Technology Fee Grant, 2013, $17,104.

GTRC travel grant to Turkey, July, 2013, $1,500.

GTRC travel grant to Lithuania, July, 2012, $750.

"Siemens Cherrypicker and Conference Paper Support" Manufacturing Research Center**,** July 2010, $6,750.

GTRC travel grant to Egypt, July, 2010, $750.

"Siemens Conference Paper Support" Manufacturing Research Center**,** September 2009, $3,200.

GTRC travel grant to Spain, April, 2009, $1,500.

"The Influence of Input Shaper Duration on Bridge Crane Operator Performance " Aayush Daftari, President's Undergraduate Research Travel Award, August 2008, $1,000.

"Dynamics of Orbit Boosting of an Electrodynamic Tethered Satellite with Input-Shaped Current" Adrit Lath, President's Undergraduate Research Award, July 2008, $1,500.

"Robustness of Negative Input Shaping" Aika Yano, President's Undergraduate Research Travel Award, May 2008, $1,000.

"Generator for Mobile Boom Crane", Materials, Supplies, & Travel Grants for Undergraduate Research, April. 2008, $1,500.

GTRC travel grant to Turkey, April, 2008, $1,500.

Amazon Ex. 1004.0036

"Comparison of Command Filtering Methods for Vibration Reduction in Mechanical Systems", Anderson Smith, President's Undergraduate Research Awards, March. 2008, $1,500.

"Development of Input Shapers for Mobile Cranes", Adrit Lath, President's Undergraduate Research Awards, Nov. 2007, $1,500.

"Effect of Input Shaper Duration on Crane Operator Performance", Aaayush Daftari, President's Undergraduate Research Awards, Nov. 2007, $1,500.

"Robust Input Shaper Evaluation", Aika Yano, President's Undergraduate Research Awards, May 2007, $1,500.

GTRC travel grant to China, May, 2007, $1,500.

"Conference Travel Funding: Reduction of Double Pendulum Crane Oscillations", Dooroo Kim, President's Undergraduate Research Awards, August 2006, $1,000.

GTRC travel grant to Serbia, October, 2006, $1,278.

"Reduction of Double Pendulum Crane Oscillations", Dooroo Kim, President's Undergraduate Research Awards, December 2005, $1,500.

"Development and Testing of a Command Shaping Compensator for Nonlinear Drives", Jon Danielson, President's Undergraduate Research Awards, December, 2005, $1,000.

"Space Tethered Satellite Control", Andrew Timm, President's Undergraduate Research Awards, May, 2005, $1,500.

GTRC travel grant to IFAC (Czech Republic) & REM (France), June, 2005, $1,500.

"Use of Fluid Power to Cancel Low Frequency Vibrations", Varun Sharma, President's Undergraduate Research Awards, Jan. 2005, $1,500.

"The Effects of Input Shaping on a Flexible Nonlinear Robotic Arm with Backlash", Matthew Falkenberg, President's Undergraduate Research Awards, Jan. 2005, $1,500.

"Study of Operator Behavior and Performance Using an Input-Shaped Bridge Crane", Attir Khalid, President's Undergraduate Research Awards, April 2004, $1,000.

"Fluid Power Control of a Hyper-Active Seat for Low-Frequency Vibration Suppression", Earl Lewis, President's Undergraduate Research Awards, December 2003, $960.

GTRC travel grant to IEEE CCA (Turkey) & IEEE MED (Greece), June, 2003, $1,500.

"Vibration Reduction for High-Rise Elevators", **Vlad Patrangenaru,** President's Undergraduate Research Awards, April 2003, $800.

"Experimental Verification of Input Shaping Combined with Vibration Absorbers for Oscillatory Systems", President's Undergraduate Research Awards, April 2003, $900.

"Experimental Investigation of Input Shaping with Friction on a Solder Cell Machine", President's Undergraduate Research Awards, December 2002, $900.

"CanSat Project", President's Undergraduate Research Awards, December 2002, $500.

Georgia Tech Foundation Travel Grant to Spain, October 2002, $764.

GTRC travel grant to NCOLS 2001 (Russia), April 2001, $1,406.

Amazon Ex. 1004.0037

"Experimental Apparatus for Input-Shaped Cam Profiles", President's Undergraduate Research Awards, July 2001, $1,250.

GTRC travel grant for Japan lecture tour, October 2000, $1,231.

GTRC travel grant to Advanced Motion Control 2000, February 2000, $1,250.

Other Sources

SURE & SHARP student support (Marie Cox, April Pritchard, Nathan Mauch, Adam Vela, Dwayne Bobb, **Timothy Melano**, **Rory Thomas**, **Kimberly Sheafe**) May 1999 – August 2004, $4,000.

B. As Investigator

RERC on Wheeled Mobility in Everyday Life. PI Dr. Stephen Sprigle. Funding for salary, graduate student support, materials and supplies. November 2003 - October 2008. $134,725. Total project budget $4,750,000.

In-Line Optical Measurement of MicroElectroMechanical Systems (MEMS) Devices During Production. PI Dr. Thomas Kurfess. Funding provided to train high school teacher for mechatronics curriculum transfer from Georgia Tech to Cedar Grove High School. June 2003-August 2003. $6,000.

MARC Siemens - Automation and Drives. PI Dr. Steven Danyluk. Funding provided for graduate and undergraduate student support, hardware development, installation of oscillation controller on the MARC crane and development of portable bridge and tower cranes. August 2002 – August 2012, $889,429.

HUSCO/Ramirez Laboratories for Fluid Power and Motion Control. PI Dr. Wayne Book. Funding for graduate student support, hardware development, and travel. August 2002-July 2004. $42,775.

F. Other Scholarly and Creative Accomplishments

Patents

[1] W. Singhose, N. Singer, W. Rappole, S. Derezinski, and K. Pasch, "Methods and Apparatus for Minimizing Unwanted Dynamics in a Physical System," US Patent US 5,638,267, June 10, 1997, 1997.

[2] R. Eloundou and W. Singhose, "Command Generation Combining Input Shaping and Smooth Baseline Commands," Patent US 6,920,378, July 19, 2005, 2005.

[3] K. L. Sorensen, W. Singhose, and S. Dickerson, "Combined feedback and command shaping controller for multistate control with application to improving positioning and reducing cable sway in cranes " Patent US 7,970,521, June 28, 2011, 2011.

[4] W. Singhose and D. Kim, "Methods and Systems for Double-Pendulum Crane Control," Patent US 8,235,229, August 7, 2012, 2012.

[5] W. Singhose and K. Peng, "Crane Control Systems and Method," US Patent US9,132,997 Patent Appl. 13/642,075, Sept. 15, 2015.

[6] W. Singhose and J. Vaughan, "Methods and Systems for Improving Positioning Accuracy," US Patent US 8,975,853 B2 Patent Appl. 2011/0298409 A1, 2015.

[7] K. L. Sorensen, W. Singhose, and S. Dickerson, "Crane Motion Control," Patent US 9,776,838, October 3, 2017, 2017.

Amazon Ex. 1004.0038

[8] W. Singhose and F. Schlagenhauf, "Systems and Methods for Tracking Body Movement," US Patent Appl. PCT/US18/41468, 2018.

G. Other Professional
Conferences Organized
NSF Planning Visit: Large Flexible Space Structures, Tokyo Japan, 12/11-12/15/2005.
Siemens Automation and Drives Conference at Georgia Tech Lorraine, 11/29-11/30/04.

Conference Sessions Organized
"Command Shaping in Mechatronics." 7th Mechatronics Forum International Conference, 2000, Atlanta, GA.
"Tutorial: Input Shaping and Time Delay Control of Maneuvering Flexible Structures." 2002 American Controls Conference, Anchorage, AK.

Conference Sessions Chaired
2007 American Control Conference, New York, NY
2006 ICAMEM, Tunis, Tunisia
2004 Japan-USA Symposium on Flexible Automation, Denver, CO.
2004 American Control Conference, Boston, MA.
2003 American Control Conference, Denver, CO.
2002 2nd IFAC Conference on Mechatronic Systems, Berkeley, CA.
2002 6th International Conference on Motion and Vibration Control, Saitama, Japan
2002 Japan-USA Symposium on Flexible Automation, Hiroshima, Japan.
2002 American Control Conference, Anchorage, AK.
1999 IEEE Conference on Control Applications, Kona, HA.
1998 IEEE Conference on Control Applications, Trieste, Italy.
1995 IFToMM Ninth World Congress on the Theory of Machines and Mechanisms, Milan, Italy.

V. Education

B. Individual Student Guidance

B1. Ph.D. Students

B1.a. Graduated Ph.D. Students

1) Kris Kozak. Started Fall '99. Passed qualifier examination Fall '00. Ph.D. awarded May '03, "Investigation of Input Shaping for Parallel Manipulators." Currently at Southwestern Research Institute. (coadvised with Dr. Ebert-Uphoff).
2) Erika Biediger-Ooten. Started Fall '98. M.S. Dec. '00. Passed qualifier examination Fall '01. Ph.D. awarded May '05, "Vibration Reduction Using Command Generation in Formation Flying Satellites." Currently Engineer at Exxon-Mobil.
3) Mike Robertson. Started Fall '98. M.S. May '01. Passed qualifier examination Spring '02. Ph.D. awarded May '05, "Command Generation for Tethered Satellite Systems". Currently Professor at the Naval Academy
4) Joel Fortgang. Started Fall '99. M.S. May '02. Passed qualifier examination Spring '02. Ph.D. awarded May '06. "Combined Mechanical and Command Design for Micro-Milling Machines".
5) John Huey. Started Fall '01. M.S. August '03. Passed qualifier examination Fall '03. Ph.D. awarded August '06. "Concurrent Design of Feedback and Command Shaping Control". Currently Controls Engineer - GE Aviation.

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6) Jason Lawrence. Started Fall '00. M.S. August '02. Passed qualifier examination Fall '03. Ph.D. awarded August ’06. “Control of Tower Cranes”, Currently Mechanical Engineer at Lexmark.
7) Joshua Vaughan. Started Fall ’02. M.S. May ’04, Ph.D. awarded August ’08” Dynamics and Control of Mobile Cranes”. Currently professor at University of Louisiana-Lafayette.
8) Khalid Sorensen. Started Fall ’03. M.S. May ’05, Ph.D. awarded August ’08. “Combined Feedback Control and Command Shaping of a Bridge Crane.”
9) Adan Vela. Started Fall ’06. Ph.D. awarded Dec. ’11. “Bounds on Controller Taskload Implementing Conflict-Resolution Algorithms in an Airspace.”
10) Kelvin Peng, Started Spring ’08, Ph.D. awarded Dec. ’13, “Methods for Improving Crane Performance and Ease of Use.”
11) Ehsan Maleki, Started Fall ’08, Ph.D. awarded Dec. ’13, “Control of Human-Operated Machinery with Flexible Dynamics.”
12) James Potter, Started Fall ’09, Ph.D. awarded Dec. ’13, “Input-Shaped Manual Control of Helicopters with Suspended Payloads.”
13) Arto Kivila, Started Fall ‘13, Ph.D. awarded Aug.’17, “Modeling, Estimation and Control for Serial Flexible Robot Arms.”
14) Daichi Fujioka, Started Fall ’10, Ph.D. awarded Aug.’17, “Input-Shaped Model Reference Control for Flexible Systems.”
15) Christopher Adams, Started Fall ’12, Ph.D. awarded Dec. ’18, “Modeling and Control of Backdrivable Flexible Systems”
16) Ali AlSaibie, Started Fall ‘12, Ph.D. awarded Dec. ’18, “Mechatronic Design of Micro Autonomous Underwater Vehicles for Confined Spaces”
17) Arnoldo Castro, Started Spring ’16, Ph.D. awarded Dec. ’19, “Dynamics and Control of Self-Balancing Transporters”

B1.b. In Process Ph.D. Students

1) Alison Jenkins, Started Spring ’20, Passed Quals Fall 2021
2) Tyler Rome, Started Spring ’21, Passed Quals Fall 2022

B2. M.S. Students (Indicate Thesis Option for Each Student)

B2.a. Graduated M.S. Students

1) Mike Kenison. Graduated Dec. '99 - "Command Generation in Control System Design for Systems with Parameter Variations." Currently Development Engineer, Schlumberger.
2) Karen Grosser. Graduated May '00 - "Input Shaping for Telerobotic Manipulators." Currently Development Engineer, Schlumberger.
3) Erika Ooten. Graduated Dec. '00 - "Command Generation for Flexible Systems Using Numerator Dynamics and Sliding Mode Control." Currently Engineer at Exxon-Mobil.
4) Kris Kozak. Graduated Aug. '01 - "Dynamic Analysis of Parallel Manipulators and Digital Input Shaper Computation Using Linear Optimization." Currently a Post-doc at Tsinghua University.
5) Mike Robertson. Graduated May '01. "Methods for Generating Deflection-Limiting Commands." Currently Post-doc at Air Force Research Lab.
6) Joel Fortgang. Graduated May '02 - "Concurrent Design of Input Shaping and Vibration Absorbers."
7) Jason Lawrence. Graduated August '02 - " Using Input Shaping to Optimize Point-to-Point Motions in PD Controlled Systems with Coulomb Friction."
8) Raynald Eloundou. Graduated August '02 - "Investigation of Various Reference Commands for Vibration Reduction." Currently Mechanical Engineer at Hitachi.

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9) John Huey. Graduated August '03. “Dynamics and Vibration Control of Large Area Manipulators.”
10) Sam Klooster. Graduated Spring ’04. “Design of an Active Safety Seat.” Currently mechanical engineer at Lockheed Martin.
11) Joshua Vaughn. Graduated Spring ’04. “Active and Semi-Active Control to Counter Vehicle Payload Variation.” (coadvised with Dr. Nader Sadegh)
12) Khalid Sorensen. Graduated Spring ’05.”A Combined Feedback and Command Shaping Controller for Improving Positioning and Reducing Cable Sway in Cranes”
13) Vlad Patrangenaru. Graduated Spring ’06. “Design of Active Wheelchair Seats to Compensate for Extensor Tone in Children.”
14) Azeem Meruani, Spring ’06. “Tweel Technology Tires for Wheelchairs and Instrumentation for Measuring Everyday Wheeled Mobility”
15) David Blackburn. Graduated Summer ’06. “Control of Space Tethers.”
16) Jim Kitchen. Graduated Summer ’06. “Design of an Dynamic Wheelchair Seat.”
17) Ray Manning. Graduated Spring ’08 “Improving the Control of Two-Mode Flexible Systems with Input Shaping”
18) Jon Danielson. Graduated Summer ’08 “Mobile Boom Crane Dynamics and Control”
19) Andreas Rauch, Graduated Summer ’08 “Stability Analysis of Mobile Boom Cranes”
20) Daichi Fujioka, Graduated Summer ‘10, “Dynamic Stability of Mobile Boom Cranes”
21) Kelvin Peng, Graduated Fall ‘09, “Interfaces and Control Systems for Intuitive Crane Control”
22) Ehsan Maleki, Graduated Summer ’10, “Dynamics and Control of a Small-Scale Mobile Boom Crane”
23) Brice Pridgen, Graduated May ’11, “Comparison of Polynomial Profiles and Input Shaping for Industrial Applications”
24) Arnoldo Castro, Graduated Summer ’12, “Modeling and Dynamic Analysis of a Two-Wheeled Inverted-Pendulum”
25) Christopher Adams, Graduated Summer ’12, “Modeling and Control of Helicopters Carrying Suspended Loads”
26) Eileen Hernandez, Graduated Fall ’12, “Dynamic Characterization and Analysis of Aerial Lifts”
27) Arto Kivila, Graduated Aug. ’13, “Touchscreen Interfaces for Machine Control and Education”
28) Alex Miller, Graduated Dec. ’13, “Dynamics and Control of Dual-Hoist Cranes Moving Distributed Payloads”
29) Athony Garcia, Graduated Dec. ’14, “Improved Friction, Contact and Dynamic Simulation Model to Study the Behavior of Payloads During Off-Centered Crane Lifts”
30) John Harber, Graduated May ’16, “A Dual Hoist Robot Crane for Large Area Sensing”
31) Sima Rishmawi, Graduated May ’16, “Tip-Over Stability Analysis of Crawler Cranes in Heavy Lifting Applications”
32) Yujia Yang Graduated May ’17, “Automated Longitudinal Payload Lift-up Using Bridge Cranes”
33) Nickolas Johnson, Graduated May’17, “Control of a Folding Quadrotor with a Slung Load Using Input Shaping.”
34) Franziska Schlagenhauf, Graduated Aug. ’17, “A Kinematic Upper Body Model for Evaluating Clothing”
35) Xiaoshu Liu, Graduated Dec. ’17, “Numerical Investigation of Affordable 2D Lidar Sensors for Autonomous Driving Under a Specially-Structured Driving Environment”
36) Luk, Henry, Graduated May '20, Non-thesis Master's, Project: Dynamics of LRA Devices Within Wrist Bands

Amazon Ex. 1004.0041

37) Lyman, Colin, Graduated August '21, Non-thesis Master's, Project: Development of Multi-LRA Devices
38) Ravishankar, Praveen, Graduated August '21, Non-thesis Master's, Project: Development of Haptic Signals for Multi-LRA Devices
39) Schmidt, Ryan, Graduated August '22, Non-thesis Master's, Project: Sensing of LRA Back EMF

B2.b. In Process M.S. Students

1) Hernandez, Melissa

B3. Undergraduate Students

Kanako Abe, Hafeez Alam, Ulf Andresen, Derek Bastien, Fernando Bazerghi, Esteban Benero (SURE), Dustin Bergman, Dwayne Bobb (SURE - Morehouse College), Carrie Boles, Justis Brogan, Jeff Clement, Maria Cox (SURE), Jon Danielson, Chuck Devane, Raynald Eloundou, Adrian Erb (Swiss), Matthew Falkenberg (PURA), Brian Fatkin, Jonathon Fonseca, Craig Forest, Damien Gaudry, Terry Hall, Samir Idnani, Walker Inman, Taft Jones (SURE), Paul Jurek, Attir Khalid, Dooroo Kim, Jae-Hyung Kim, Nathan Knight, Prerana Kumar, Bumsoo Lee, Caitlyn Leksana, Earl Lewis, Alan Martin, Timothy Melano (SURE – Berkeley), Ben Myers, Chad Nicholson, Noav Nossenson (SURE), Patrick Opdenbosch, Adnan Pandjou, Tejan Poage, Jessica Powell, April Pritchard (SURE), Devshan Renganathan, Caroline Rhee, Nathan Ritz, Nick Sabogal, Prachi Sahoo, Dushyant Sharma, Varun Sharma (PURA), Kimberly Sheafe (SURE – Stanford), Anderson Smith (PURA), Jonathon Smith, Josh Spiers, Christoph Stäheli (Swiss), Lee Stokes, Art Terdpravat, Brandon Terrell, Rory Thomas (SURE – John Hopkins), Andrew Timm, Adam Vela (SURE), Rolf Weiss (Swiss), Amber Welsh, Kevin Yang, Aika Yano, Jieun Yoo.

B5. Mentorship of Postdoctoral Fellows or Visiting Scholars

B5.a. Postdoctoral Fellows

1) Dr. Kris Kozak. June 2003-Dec. 2003, "Development of a Hyperactive Seat."
2) Dr. Joshua Vaughan. Jan. 2010–August 2012, "Development of an Aerospace Manufacturing Center."
3) Dr. Christopher Adams. Jan. '19-present, "Input Shaping Mobile Crane Controllers"

B5.b. Visiting Scholars

1) Prof. Seong-Wook Hong, Kumoh National University, Kumi, Korea, Feb. 2004-Feb. 2005.
2) Prof. Juan de Juanes Marquez, Escuela Tecnica Superior de Ingenieros Industriales (ETSII), Madrid, Spain, June 2005-Dec. 2005.
3) Prof. Yoon-Gyeoung Sung, Chosun University, Gwangju, Korea, July 2006-August 2007.
4) Prof. Mingxiao Dong, Shandong Jianzhu University, China, Dec 2007-May 2008
5) Ji Sup Joon, Division Director, Advanced Fuel Cycle System Eng., Korea Atomic Energy Research Institute, Korea, September 2008-September 2009
6) Prof. Zhang Yizhuo, North East Forestry University, Harbin, China, Dec. 2009 – Dec. 2010
7) Prof. Youmin Hu, Huazhong University of Science & Technology, Wuhan, China, Jan. 2010-Jan 2011
8) Prof. Kyoungseok Park, Kumoh National Institute of Technology, Gumi, Korea, June 2010-June2011
9) Prof. Jie Huang, Beijing Institute of Technology, August 2014-July 2105
10) Prof. Dongjoo Kim, Kumoh National Institute of Technology, Gumi, Korea, Feb. 2016 - Feb. 2017
11) Stanislao Grazioso, Università degli Studi di Napoli "Federico II", Napoli, Italy, August 2016-Dec. 2016

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12) Dr. Ali AlSaibie, Kuwait University, July-August 2023

C. Educational Innovations and Other Contributions

a) New Course Development

ME 6404 - Advanced Control System Design and Implementation. Course was completely overhauled, updated, and expanded for the Fall of 2001. The result was essentially a new course. A book, *Command Generation for Dynamic Systems*, was written to compliment the course curriculum. A portable robotic bridge crane was constructed so that this course could be taught at Georgia Tech Lorraine in the fall of 2004. Siemens sponsored the crane construction and also a two-day conference at GTL that centered on the crane and the associated curriculum development: http://singhose.marc.gatech.edu/SiemensGTL/. A portable tower crane was also constructed for the course. The tower crane was used at Tokyo Tech for 2 years. Students conducted remote operation tests via the internet. The course was also taught at MIT during the fall of 2010 in conjunction with Professor Warren Seering of MIT. The course was expanded in the fall of 2011 to include a distance learning curriculum that uses remote-operated labs.

ME 4863 – Emerging Technology Law. Course was designed to educate engineering students about legal constructs that effect engineering activities in the area of emerging technology. The course is cross listed as BME4853. The course has two main components: Product Liability and Intellectual Property. In addition to weekly lectures, the course includes weekly studio sessions and mock trials.

b) Laboratory Experiments Developed: The new version of Advanced Control System Design and Implementation has a major laboratory component. An entire sequence of laboratory projects were developed for the course using the large bridge crane in the MARC building and hardware in the Love Building hydraulics laboratory. The crane in the MARC building has been equipped with oscillation-reducing technology that is taught in ME6404. The crane was also used as a testbed in the senior-level experimental engineering course, ME4055. Several laboratory projects were developed for ME2110, Creative Decisions and Design. A paper describing these developments was presented at the 2nd IFAC Conference on Mechatronic Systems. A two-week curriculum on PLC programming was developed along with PLC workstations to conduct laboratory activities. Hands-on control experiments for ME4452 (Control Systems) were developed to utilize the NI MyRIO controller along with a flexible-beam experimental setup.

c) Interactive Instructional Materials Developed: Dr. Singhose has developed interactive textbooks for both introductory mechanical design (with an emphasis on mechatronics) and advanced control system implementation (with an emphasis on command-shaping control). Features of interactive textbooks include: embedded videos that can be viewed with the tap of a finger, picture slideshows, user-controlled simulations, and interactive charts that accept user input and provide immediate feedback. Dr. Singhose has also developed a series of remote-operated experimental cranes and aerial lifts that have been used extensively in educational activities.

VI. Service

A. Professional Contributions

Journals

Int. Journal of Control, Automation, and Systems (IJCAS), Editorial Board Member, 2005-Present
Mechatronics, Associate Editor, 2008

Amazon Ex. 1004.0043

Control Engineering Practice, Designated Editor, 2007-2010

Conferences

Asian Control Conference, Associate Editor of Contributed Papers, 2017
Int. Symposium on Flexible Automation, Program Chair, 2008
IEEE/ASME Int. Conference on Advanced Intelligent Mechatronics, Program Committee, 2007
Int. Symposium on Flexible Automation, Program Committee, 2006
Advanced Intelligent Mechatronics Program Committee, member, 2005
International Conference on Motion and Vibration Control Program Committee, member, 2004
American Control Conference Program Committee, member, 2004
Japan-USA Symposium on Flexible Automation Program Committee, member, 2004

Reviews

National Science Foundation, Division of Design Manufacturing and Industrial Innovation, proposal reviewer
National Science Foundation, Sensors and Sensor Systems, proposal reviewer
AIAA Journal of Guidance, Control, and Dynamics, reviewer
AIAA Journal of Spacecraft and Rockets, reviewer
AIAA Guidance, Navigation, and Control Conference, reviewer
American Control Conference, reviewer
ASME Journal of Dynamic Systems, Measurement, and Control, reviewer
ASME Design Engineering Technical Conferences, reviewer
ASME Journal of Vibration and Acoustics, reviewer
Automatica, reviewer
Control Engineering Practice, reviewer
Control Systems Technology, reviewer
IEEE/ASME Transactions on Mechatronics, reviewer
IEEE Transactions on Systems, Man, and Cybernetics, reviewer
IEEE Conference on Control Applications, reviewer
IEEE Int. Conference on Robotics and Automation, reviewer
Industrial & Engineering Chemistry Research, reviewer
Journal of the Franklin Institute, reviewer
Journal of Sound and Vibration, reviewer
Mechatronics, reviewer
Mechatronics 2000, Panel reviewer

Industrial Project Advising

Milliken Summer Faculty Challenge – 2000

B. Public and Community Service

Standards Committees

IEEE Virtual Reality and Augmented Reality Standards Working Group, 2018-2019
ASTM F15.18 - Cribs, Toddler Beds, Play Yards, Bassinets, Cradles and Changing Tables, 2018-2019
ASTM D13-Textiles, D13.66 – Sewn Product Automation subcommittee member, 2017-2019
ASTM F08.52, F08.67 - Pole Vault Pole Testing and Pole Vault Landing Pads subcommittee, member, 2000-2006
USA Track & Field Pole Vault Equipment Task Force, member.

C. Institute Contributions

Organized and supervised Georgia Tech Rescue Robot Team, 2013-present
Organized and supervised Georgia Tech CanSat Team, 2002-2012

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ASME Student Group, Faculty Advisor, 2007-2012
SME Student Group, Faculty Advisor, 2001-2007
Pole vault coach for Georgia Tech track and field team (1998-2000)
2009 Chair of Director of Design Search Committee
2015 Chair of Zeigler Woodruff School Outstanding Educator Award Committee

Woodruff School Committee member:
2023 Zeigler Outstanding Educator Award Committee
2022 Zeigler Outstanding Educator Award Committee
2021-23 RPT
2019-21 Graduate Student Development
2015-16 RPT
2016-17 PPR
2013-16 Undergraduate
2012 Director of Design Search Committee
2008 HR Director Search Committee
2006-07 Undergraduate
2003-04 Faculty Awards
2001-03 Undergraduate
2000 Faculty Recruiting
1999 Graduate
1998 Undergraduate

Amazon Ex. 1004.0045