

**Thomas G. Sugar**  
**Arizona State University**  
**Ira A. Fulton Schools of Engineering**  
**School of Manufacturing Systems and Networks**

**Barrett, The Honors College**  
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## **1. ACADEMIC APPOINTMENTS**

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2019- Present	Arizona State University	Mesa, AZ
	<i>Associate Dean, Barrett, The Honors College, Polytechnic Campus</i>	
2022- Present	Arizona State University	Mesa, AZ
	<i>President's Professor</i>	
	Manufacturing Systems and Networks	
2013- 2022	Arizona State University	Mesa, AZ
	<i>Professor</i>	
	Department of Engineering	
2007-2013	Arizona State University	Mesa, AZ
	<i>Associate Professor</i>	
	Department of Engineering	
	Classes: Introduction to Engineering 1, Introduction to Engineering II, EGR 201, EGR 202, studio based instruction, EGR 301 Junior project course, EGR 444 Engineering Design, EGR 445 Mechanical Engineering Systems, EGR 401, EGR 402, Senior Projects, EGR Robotics 1, EGR Robotics 2, EGR 550, EGR 608	
2005-2007	Arizona State University	Mesa, AZ
	<i>Assistant Professor</i>	
	Department of Engineering	
	Classes: Introduction to Engineering 1, Introduction to Engineering II, EGR 201, studio based instruction	
1999-2005	Arizona State University	Tempe, AZ
	<i>Assistant Professor</i>	
	Design group in the Mechanical and Aerospace Engineering Department	
	Classes: Mechanism Analysis and Design, Mechanical Systems Design, Mechanical Design and Control of Robots, Introduction to Engineering, Engineering Design, Computer Aided	

## Manufacturing and Control

1995–1999 GRASP Laboratory

Philadelphia, PA

### *Research Fellow*

Designed an integrated system for coordinating a small team of mobile robots in tasks that involve grasping large objects and transporting them in an environment with obstacles. The system included three robots with different operating systems, a wireless communication protocol, and specially designed embedded motor control boards.

1996–1997 U. of Pennsylvania

Philadelphia, PA

### *Graduate Advisor for the Gateway Project*

Supervised several teams of undergraduates in designing and building robotic and rehabilitative devices in a multi-university, collaborative design project.

## **2. INDUSTRIAL EXPERIENCE**

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1992–1995 W.L. Gore and Associates

Newark, DE

### *Project Engineer*

Responsible for designing and developing test equipment for quality control of Gore Products insuring waterproofness. Awarded U.S. Patent # 5329807. Conducted statistical studies and evaluation; developed a sales brochure; supervised construction and manufacture of equipment, and installed machines in our customers' factories worldwide.

Conducted experimental studies on web handling equipment to improve laminate quality.

1989 General Motors, Saturn Subsidiary

Troy, MI

### *Internship*

Collected noise and vibration data for squeak and rattle evaluations of the Saturn Sedan using microphones, accelerometers, and a digital tape recorder. Built test setups to determine the problem areas which needed to be redesigned.

## **3. LICENSES**

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Professional Engineer, PE # 14120, Delaware

#### **4. AWARDS AND HONORS**

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- a. 2025 Fulton Schools of Engineering Top 5% Teaching Award
- b. President's Professor 2022
- c. Faculty Excellence Award, 2013, Arizona State University Polytechnic Campus, Scholarly and Creative Activities
- d. Outstanding Faculty Mentor Award, 2011-2012, Arizona State University Polytechnic Campus
- e. Researcher of the Year, 2006-2007 Arizona State University Polytechnic Campus.
- f. 1<sup>st</sup> place at the Arizona Regional of the FIRST Robotics Program in January 2003.
- g. Mentored a team for the Raytheon Design Competition between the three Arizona Universities, in 2003, 2004, and 2005, earned 1<sup>st</sup> place in 2004

#### **5. PRINCIPAL AREAS OF TEACHING AND RESEARCH**

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Teaching: Kinematics, Mechanism Analysis and Design, Mechanical System Design, Robotics, Introduction to Engineering, Engineering Design, Computer Aided Manufacturing and Control, Engineering 1, Engineering II, EGR 201, EGR 202, EGR 301, EGR 444, EGR 445, EGR 401, EGR 402

Research: Compliant actuators used in physical therapy devices, muscle assistance, and gait

Prosthetic systems

Medical Robotics

Spatial navigational principles with applications to mobile robotics

Mobile Robot Cooperation with dynamic grasping and manipulation of objects

Locomotion haptics designing an omni-directional treadmill

ASU Research Goals:

Health Systems & Technology

Research includes: powered prosthetics, wearable robotic exoskeletons, rehabilitation robotics

Director of the Integrated Manufacturing and Engineering Laboratory, 2004 and 2005

Collaborations:

Dr. M. McBeath in Psychology, Topic: Spatial Navigation

## 6. EDUCATION

**University of Pennsylvania   Mechanical Engineering and Applied Mechanics Ph.D., 1999**  
Dissertation: Design and control of cooperative mobile robotic systems.

**University of Pennsylvania   Mechanical Engineering and Applied Mechanics   M.S.E., 1992**  
Thesis: Design and control of an in-parallel pneumatically actuated manipulator.

**University of Pennsylvania   Mechanical Engineering and Applied Mechanics B.S.E., 1991**  
School of Engineering and Applied Sciences

**University of Pennsylvania B.S. in Economics B.S.E., 1991**  
The Wharton School of Business Concentration in Entrepreneurial Management  
Management and Technology Program.

## 7. SCIENTIFIC AND PROFESSIONAL SOCIETIES

ASME 1997-present, ASME Fellow

## Concentration in Entrepreneurial Management

IEEE 1999-present, IEEE Senior Member

## RESEARCH AND SCHOLARSHIP

### PUBLICATIONS

#### Refereed Archival Journal Papers

Google Scholar: H Index 45, 7,676 Citations, data collected on 1/6/2026

J52. Bhat, Sandesh G., Emily J. Miller, Paul Kane, Kevin W. Hollander, Claudio Vignola, Alexander Y. Shin, Thomas G. Sugar, and Kenton R. Kaufman. "Enhanced Functionality Using a Powered Upper Extremity Exoskeleton in Patients With Brachial Plexus Injuries." *IEEE Transactions on Neural Systems and Rehabilitation Engineering* (2025).

J51. Claudio Vignola, Sandesh G Bhat, Kevin Hollander, Paul Kane, Emily Miller, William Brandon Martin, Alexander Y Shin, Thomas G Sugar, Kenton R Kaufman, "Design and Development of a Powered Myoelectric Elbow Orthosis for Neuromuscular Injuries" *Military Medicine*, Volume 189, Issue Supplement\_3, September/October 2024, Pages 585–591, <https://doi.org/10.1093/milmed/usae196>

J50. Cooper, Rory A., George Smolinski, Jorge L. Candiotti, Shantanu Satpute, Garrett G. Grindle, Tawnee L. Sparling, Michelle J. Nordstrom, Xiaoning Yuan, Allison Symsack, Chang Dae Lee, and et al. 2024. "Current State, Needs, and Opportunities for Wearable Robots in Military Medical Rehabilitation and Force Protection" *Actuators* 13, no. 7: 236. <https://doi.org/10.3390/act13070236>

J49. Vanderlinden, A. O., Nevisipour, M., Sugar, T., Lee, H. "Reduced trunk movement control during motor dual-tasking in older adults." *Human Movement Science* 95 (2024). <https://doi.org/10.1016/j.humov.2024.103223>.

J48. Mende, M., Noble, S. & Sugar, T. From homo sapiens to homo superior? Wearable robotics as the platform for transhumanist marketing. *J. of the Acad. Mark. Sci.* 51, 757–766 (2023). <https://doi.org/10.1007/s11747-023-00949-z>

J47. Nevisipour, Masood, Thomas Sugar, and Hyunglae Lee. "Multi-tasking deteriorates trunk movement control during and after obstacle avoidance." *Human Movement Science* 87 (2023): 103053.

J46. Li, Dongting, Emiliano Quinones Yumbla, Alyssa Olivas, Thomas Sugar, Heni Ben Amor, Hyunglae Lee, Wenlong Zhang, and Daniel M. Aukes. "Origami-Inspired Wearable Robot for Trunk Support." *IEEE/ASME Transactions on Mechatronics* (2022), doi: 10.1109/TMECH.2022.3220136.

J45. Martin, W., Boehler, A., Hollander, K., Kinney, D., Hitt, J., Kudva, J., & Sugar, T. (2022). Development and testing of the aerial porter exoskeleton. *Wearable Technologies*, 3, E1. doi:10.1017/wtc.2021.18

J44. Jason Olson, Sambarta Ray, Thomas Sugar, Claire Honeycutt and Sangram Redkar “Design of active ankle foot orthotics for gait assistance and fall prevention” *Int Rob Auto J.* 2020;6(3):106–113.

J43. Juan De La Fuente, Susheelkumar C. Subramanian, Thomas G. Sugar, Sangram Redkar, “A robust phase oscillator design for wearable robotic systems,” *Robotics and Autonomous Systems*, 128, 2020, <https://doi.org/10.1016/j.robot.2020.103514>.

J42. T. G. Sugar, E. H. Sinit斯基, J. M. Wilken, S. Redkar, M. A. Holgate, “Phase plane analysis of walking with applications in controlling bipeds and prostheses,” *International Robotics & Automation Journal*, 6(1), 2020.

J41. P. New, A. Bates, J Da la Fuente, T. Sugar, S. Redkar, “Adaptive oscillator controller for quadruped hopping robots,” *MOJ Applied Bionics and Biomechanics*, 2019, 3(4): 85-94.

J40. P.T. Chinimilli, S. Redkar, T. Sugar, “A Two-Dimensional Feature Space Based Approach for Human Locomotion Recognition”, *IEEE Sensors Journal*, January, 2019. doi:10.1109/JSEN.2019.2895289

J39. Nathan Cahill, Thomas Sugar, Yi Ren, Kyle Schroeder, “Optimal Stiffness Design for an Exhaustive Parallel Compliance Matrix in Multiactuator Robotic Limbs,” *ASME Journal of Mechanisms and Robotics*, 2018, doi:10.1115/1.4039772.

J38. C. S. Susheelkumar, S. Redkar, T. Sugar, “Parametric resonance and energy transfer in suction stabilized floating platforms: a brief survey, *International Journal of Dynamics and Control*, vol. 5(3), pp 931-945, 2017.

J37. P. T. Chinmilli, S. Redkar, W. Zhang, T. Sugar, “A Review on Wearable Inertial Tracking based Human Gait Analysis and Control Strategies of Lower-Limb Exoskeletons,” *International Robotics and Automation Journal*, 3(7), 2017.

J36. Juan De la Fuente, Thomas G. Sugar, Sangram Redkar, “Nonlinear, Phase-Based Oscillator to Generate and Assist Periodic Motions,” *ASME Journal of Mechanisms and Robotics*, 9(2), 2017, DOI: 10.1115/1.4036023.

J35. Chase Wheeler, Thomas Sugar, Eduardo Fernandez, Arjun Narayanan, Sangram Redkar Load Carrying Assistance Device Pogo Suit, *IAES International Journal of Robotics and Automation (IJRA)* 5 (3), 2016

J34. Grimmer, M., Holgate, M., Holgate, R., Boehler, A., Ward, J., Hollander, K., Sugar, T., Seyfarth, A., “A Powered prosthetic ankle joint for walking and running,” *BioMedical Engineering Online*, 15(Suppl 3):141, DOI 10.1186/s12938-016-0286-7, 2016.

J33. Vamsi Manchala, Sangram Redkar and Tom Sugar, ‘Using Deep Learning for Human Computer interface via Electroencephalography’, *IAES International Journal of Robotics and Automation (IJRA)* Vol 4, No 4: December 2015

J32. Aaditi Joshi, Tom Sugar and Sangram Redkar, 'Characterization of Sandia MEMS Accelerometer', *Bulletin of Electrical Engineering and Informatics*, Vol. 4, No. 4, December 2015, pp. 320~333.

J31. CS Susheel Kumar, Sangram Redkar and Tom Sugar, "Parametric Resonance and Energy Transfer in Suction Stabilized Floating Platforms-A Brief Survey". *International Journal of Nonlinear Dynamics*, October 2015. DOI: 10.1007/s40435-015-0210-1

J30. W. Wang, M. K. McBeath, T. G. Sugar, "Optical Angular Constancy is Maintained as a Navigational Control Strategy when Pursuing Robots Moving along Complex Pathways," *Journal of Vision*, vol 15(3), 2015.

J29. T. G. Sugar, A. Bates, M. Holgate, J. Kerestes, M. Mignolet, P. New, R. K. Ramachandran, S. Redkar, C. Wheeler, "Limit Cycles to Enhance Human Performance based on Phase Oscillators," *ASME Journal of Mechanisms and Robotics*, 7(1), February 2015 doi: 10.1115/1.4029336.

J28. W. Wang, M. K. McBeath, T. G. Sugar, "Navigational strategy used to intercept fly balls under real-world conditions with moving visual background fields," *Attention, Perception, and Psychophysics*, vol 77(2), February 2015, pages 613-625.

J27. T. G. Sugar, K. W. Hollander, A. Boehler, and J. Ward, "Comparison and Analysis of a Robotic Tendon and JackSpring Actuator for Wearable Robotic Systems," *ASME Journal of Medical Devices* 7(4) 2013.

J26. D Bernardin, H. Kadone, D. Bennequin, T. Sugar, M. Zaoui, A. Berthoz, "Gaze Anticipation during Human Locomotion", *Experimental Brain Research*, vol 223, 2012, pp 65-78.

J25. Jeffrey Ward, Thomas Sugar, Alexander Boehler, John Standeven, Jack R. Engsberg, "Stroke Survivors' Gait Adaptations to a Powered Ankle-Foot Orthosis, *Advanced Robotics*, vol 25, (15), November 15, 2011 pp. 1879-1901.

J24. Sangram Redkar, Tom Sugar, Anshuman Razdan, Ujwal Koneru, Bill Dillard, and Karthik Narayanan, ' Using Inertial Measurement to Sense Crash Test Dummy Kinematics', *International Journal of Modern Engineering*, vol 10(2), 2010.

J23. Joseph K. Hitt, Thomas G. Sugar, Matthew Holgate, and Ryan Bellman, "An Active Foot-Ankle Prosthesis with Biomechanical Energy Regeneration", *ASME Journal of Medical Devices*, vol 4(1) 2010.

Number 1 downloaded paper for the journal in April and May 2010

J22. Hitt, J, Holgate, M, Bellman, R, Sugar, TG, Hollander, KW, "Robotic Transtibial Prosthesis with Biomechanical Energy Regeneration", *Industrial Robot: An International Journal*, vol 36(5), pp. 441-447, 2009.

**Outstanding Paper Award Winner** at the Literati Network Awards for Excellence 2010.

J21. Ronald Van Ham, Thomas G. Sugar, Bram Vanderborght, Kevin W. Hollander, Dirk Lefeber, “Compliant Actuator Designs: Review of Actuators with Passive Adjustable Compliance / Controllable stiffness for Robotic Applications”, IEEE Robotics and Automation Magazine, vol 16(3), pp. 81-94, September 2009.

### **Top Ten downloaded paper for the Magazine**

Our article is in top 10 download in February 2010

<http://ieeexplore.ieee.org/xpl/topAccessedArticles.jsp?reload=true&punumber=100>

J20. B Vanderborght, R. Van Ham, D. Lefeber, T. G. Sugar, K. W. Hollander, “Comparison of Mechanical Design and Energy Consumption of Adaptable, Passive-compliant Actuators,” International Journal of Robotics Research, vol 28(1), pp. 90-103, 2009.

J19. I. Dolgov, M. K. McBeath, and T. G. Sugar, “Evidence for Axis-Aligned Motion Bias: Football Axis-Trajectory Misalignment Causes Systematic Error in Projected Final Destinations of Thrown American Footballs,” Perception, 2009, doi:10.1068/p6114

J18. J. Ward, A. Boehler, D. Shin, K. Hollander, T. Sugar, “Control Architectures for a Powered Ankle Foot Orthosis,” International Journal of Assistive Robotics and Mechatronics, vol 9(2), pp. 2-13, 2008

J17. D. M. Shaffer, M. K. McBeath, S. M. Krauchunas, and T. G. Sugar, “Evidence for a Generic Interceptive Strategy,” Perception and Psychophysics, vol 70(1), pp. 145-157, 2008.

J16. T. Sugar, Jiping He, E.J. Koeneman, J.B. Koeneman, R. Herman, H. Huang, R. S. Schultz, D. E. Herring, J. Wanberg, J. Ward, and S. Balasubramanian, “Design and Control of RUPERT: a Device for Robotic Upper Extremity Repetitive Therapy”, IEEE-TNSRE Special Issue on Rehabilitation Robotics, vol 15(3), pp 336-346, September 2007.

J15. T. G. Sugar, M. K. McBeath, A. Suluh, and K. Mundhra, "Mobile Robot Interception using Human Navigational Principles: Comparison of Active versus Passive Tracking Algorithms," *Autonomous Robots*, vol 21(1), pp. 43-54, August 2006.

J14. T. G. Sugar, M. K. McBeath, and Z. Wang, “A Unified Fielder Theory for Interception of Moving Objects either Above or Below the Horizon,” *Psychonomic Bulletin and Review*, vol 13(5), pp 908-917, October 2006.

J13. K. W. Hollander, Robert Ilg, T. G. Sugar, and D. E. Herring, “An Efficient Robotic Tendon for Gait Assistance,” *ASME Journal of Biomechanical Engineering*, vol 128(5), pp. 788-791, October 2006.

J12. K. Hollander and T. G. Sugar, “Design of Lightweight Lead Screw Actuators for Wearable Robotic Applications,” *ASME Journal of Mechanical Design*, vol. 128(3), pp. 644-648, May 2006.

J11. K. Bharadwaj, T. G. Sugar, J. B. Koeneman, and E. J. Koeneman, “Design of a Robotic Gait Trainer using Spring Over Muscle Actuators for Ankle Stroke Rehabilitation,” Special Issue on Medical Devices, *ASME Journal of Biomechanical Engineering*, vol. 127, pp. 1009-1013, November 2005.

J10. M. K. McBeath and T. G. Sugar, "Natural Selection of Asymmetric Traits Operates at Multiple Levels," *Behavioral and Brain Sciences*, vol. 28(4), pp. 605-606, August 2005.

*Professor McBeath was the lead author on this paper developing the main ideas.*

J9. C. Oberle, M. K. McBeath, S. Madigan, and T. G. Sugar, "The Galileo Bias: A Naïve Conceptual Belief that Influences People's Perceptions and Performance in a Ball-Dropping Task," *Journal of Experimental Psychology: Learning, Memory, & Cognition*, vol. 31(4), pp. 643-653, 2005.

J8. T. G. Sugar and J. P. Desai, "A Framework for Kinematic and Dynamic Motion Planning for a Formation of Mobile Robots," *Journal of Intelligent Automation and Soft Computing*, vol. 10(4) pp. 307-322, 2004.

J7. D. Burns and T. G. Sugar, "Rapid Embedded Programming in the Mathworks Environment," *JCISE, Journal of Computing and Information Science in Engineering*, vol. 2(3), pp. 237-241, September 2002.

J6. T. G. Sugar and V. Kumar, "Metrics for Analysis and Optimization of Grasps and Fixtures," Special Issue on Compliance and Compliant Mechanisms, *International Journal of Robotics and Automation*, vol. 17(1), pp. 28-37, 2002.

J5. T. G. Sugar and V. Kumar, "Control of Cooperating Mobile Manipulators," *IEEE Transactions on Robotics and Automation*, vol. 18(1), pp. 94-103, 2002. Impact Factor 2.126. (Number 1 in robotics)

J4. T. G. Sugar and V. Kumar, "Design and Control of a Compliant Parallel Manipulator," *ASME Journal of Mechanical Design*, vol. 124, pp. 676-683, 2002.

J3. T. G. Sugar, "A Novel Selective Compliant Actuator," *Mechatronics*, vol. 12(9-10), pp. 1157-1171, 2002.

J2. T. G. Sugar and M. McBeath, "Robotic Modeling of Mobile Ball-Catching as a Tool for Understanding Biological Interceptive Behavior," *Behavioral and Brain Sciences*, vol. 24(6), pp 1078-1080, 2001.

J1. G. Pfreundschuh, T. G. Sugar, and V. Kumar, "Design and control of a three degree-of-freedom, in-parallel, actuated manipulator," *Journal of Robotic Systems*, vol. 11(2), pp. 103-115, 1994.

### **Reviewed Trade Journals**

T. G. Sugar, "Tight Mobile Robot Cooperation," in *Robotics and Machine Perception, SPIE*, vol. 11, pp. 4, 11, 2002.

### **Published book chapter (an edited publication):**

I. Dolgov, M.K. McBeath, and T.G. Sugar, "The influence of symmetry on perception of thrown, oblong, symmetrical projectiles in 3D," in H. Heft and K.L. Marsh (Eds.), *Studies in Perception and Action VIII*, pp. 132-135, Mahwah, NJ: Erlbaum, 2005.

Hollander, K.W., and T.G. Sugar, "Powered Human Gait Assistance", *Rehabilitation Robotics*,

editor Sashi Kommu, I-Tech Education and Publishing, August 2007, ISBN 978-3902613-01

Book Chapter: Bioinspired Legged Locomotion, Models, concepts, Control and Applications, Edited by Maziar A. Sharbafi and Andre Seyfarth, Elsevier Inc, 2017.

Chapter 9.2 Application in Daily Life (Assistive systems), Thomas G. Sugar, Jeffrey Ward, Kevin W. Hollander.

Book Chapter: The Encyclopedia of Medical Robotics, Volume 4: Rehabilitation Robotics, Editor J. P. Desai, R. Patel, A Ferreira, S Agrawal 2018.

Ankle Prosthetics and Orthotics: Trends from Passive to Active Systems, Thomas G. Sugar, Jeffrey A. Ward, Martin Grimmer.

Book Chapter: Lower-Limb Wearable Robotics, Thomas G. Sugar, David Armstrong, Bijan Najafi, Sangram Redkar, Jeffrey A. Ward, Wearable Robots, Wearable Robots, IEC, 2018

Book editor, Shaoping Bai, Gurvinder Virk, Thomas Sugar, Wearable Exoskeleton Systems: Design, control and applications, IEC, ISBN:1785613022 9781785613029

Book editor, Shaoping Bai, Gurvinder Virk, Thomas Sugar, Wearable Exoskeleton Systems: Design, control and applications, IEC, **2<sup>nd</sup> Edition 2026**

Book Chapter: Lower-Limb Wearable Robotics, Thomas G. Sugar, David Armstrong, Bijan Najafi, Sangram Redkar, Wearable Robots, Wearable Robots, IEC, **2026**

Book Chapter: Survey of industrial exoskeletons- manufacturers, products, market and challenges, Thomas G. Sugar, Borislav Marinov, Wearable Robots, Wearable Robots, IEC, **2026**

## PUBLICATIONS

### National Conference Proceedings Refereed Papers

#### **Published in Book**

C86. T. G. Sugar and M. Holgate, "Understanding Speed and Force Ratios for Compliant Mechanisms," in *Advances in Mechanisms, Robotics and Design Education and Research*, Mechanisms and Machine Science 14, V. Kumar et al (Eds): Springer International Publishing, 2013, pp. 117-129.

C85. T. G. Sugar and V. Kumar, "Control and coordination of multiple mobile robots in manipulation and material handling tasks," in *Experimental Robotics VI*, vol. 250, *Lecture Notes in Control and Information Sciences*, P. Corke and J. Trevelyan, Eds.: Springer-Verlag, pp. 15-24, 2000, ISBN 1-85233-210-7.

C84. V. Kumar, T. G. Sugar, and G. Pfreundschuh, "A Three Degree-of-Freedom In-Parallel Actuated Manipulator," in *9th CISM-IFToMM Symposium on the Theory and Practice of Robot Manipulators, RoManSy 9*, A. Morecki, G. Bianchi, and K. Jaworek, Eds. Udine, Italy: Springer-Verlag, pp. 217-226, 1992, ISBN 0-387-19834-2.

#### **Conference Papers**

C83. "Origami-inspired Wearable Robot for Trunk Support", 2023 IEEE/ASME International Conference on Advanced Intelligent Mechatronics (AIM) (AIM 2023)

C82. Brandon Martin W. et al. (2020) Aerial Porter Exoskeleton (APEX) for Lifting and Pushing. In: Moreno J.C., Masood J., Schneider U., Maufroy C., Pons J.L. (eds) Wearable Robotics: Challenges and Trends. WeRob 2020. Biosystems & Biorobotics, vol 27. Springer, Cham. [https://doi.org/10.1007/978-3-030-69547-7\\_85](https://doi.org/10.1007/978-3-030-69547-7_85)

C81. Sandesh G Bhat, Thomas G Sugar, Sangram Redkar, "Reconstruction of Ground Reaction Force Data Using Lyapunov Floquet Theory and Invariant Manifold Theory," ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2020.

C80. Sandesh G Bhat, Thomas G Sugar, Sangram Redkar, "Invariant Manifolds in Human Joint Angle Analysis During Walking Gait," ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2020.

C79. Emiliano Qui ones Yumbla, Ruby Obeng, Jeffrey Ward, Thomas Sugar, and Panagiotis Artermiadis, "Anticipatory muscle responses in transitions from rigid to compliant surfaces: towards smart ankle-foot prostheses," 2019 IEEE-RAS-EMBS International Conference on Rehabilitation Robotics (ICORR).

C78. Juan De La Fuente, Susheekumar C Subramanian, Prudhvi Tej Chinimilli, Sangram Redkar, Thomas Sugar, "The Design of Robust Phase Oscillator for Wearable Robotic Systems," ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2019.

C77. Vamsi K Manchala, Alvaro V Clara, Susheekumar C Subramanian, Sangram Redkar, Thomas Sugar, "Human Computer Interface Using Electroencephalography for Driver Behavior Classification," ASME International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, 2019.

C76. Sunny Amatya, Saivimal Sridar, Amir Salimi Lafmejani, Souvik Poddar, Thomas Sugar, and Panagiotis Polygerinos, "Design, Development and Control of a Fabric-Based, Soft Ankle Module to Mimic Human Ankle Stiffness," 2019 IEEE-RAS-EMBS International Conference on Rehabilitation Robotics (ICORR).

C75. P. Chinimilli, S. Cherangara Subramanian, S. Redkar, T. Sugar, "Human Locomotion Assistance Using Two-Dimensional Features Based Adaptive Oscillator," IEEE WearRAcon 2019.

C74. S.G. Bhat, S. Cherangara Subramanian, J. Olson, S. Redkar, and T. G. Sugar, "Analysis of a Periodic Force Applied to the Trunk to Assist Walking Gait," IEEE WearRAcon 2019.

C73. S.G. Bhat, S. Redkar, T.G. Sugar, "Development of a Passive Prosthetic Ankle with Slope Adapting Capabilities," ASME IDETC 2018.

C72. Holgate, R., Thomas Sugar, "Decoupling Stiffness from Position in Joint Mechanisms: Applied to Powered Ankle Prosthesis," ASME IDETC 2017.

C71. Holgate, R., Thomas Sugar, Audrey Nash, Jasper Kianpour, Crag T. Johnson, Edwin, Santos, "A Passive Ankle-Foot Prosthesis with Energy return to Mimic Able-Bodied Gait," ASME IDETC 2017.

C70. Cahill, Nathan M., Matthew Holgate, Kyle Schroeder, Yi Ren, Thomas G. Sugar, "Understanding Power Loss due to Mechanical Antagonism and a New Power-Optimal Pseudoinverse for Redundant Actuators," ASME IDETC 2017.

C69. Sugar, T. G., Sangram Redkar, Joseph K. Hitt, "Wearable Robots for Worker Assistance,

Waste Management Conference, 2017.

C68. Cahill, Nathan, Yi Ren, Thomas Sugar, "Mechanical Specialization of Robotic Limbs," ICRA 2017.

C67. Sugar, T. G, Redkar, S., "Bioinspired Controller Based on a Phase Oscillator", ICNR Conference, Springer International Publishing, Converging Clinical and Engineering Research on Neurorehabilitation II, 2017.

C66. Sugar, T. G, Fernandez, E., Kinney, D., Hollander, K. W., Redkar, S., "HeSA, Hip Exoskeleton for Superior Assistance", WeRob Conference, Wearable Robotics: Challenges and Trends, 2017.

C65. Cahill, N., Holgate, M., Schroeder, K., Sugar, T.G., "Advanced Parallel Actuation of a Serial Robotic Leg", ASME International Design, Engineering, Technical Conferences, IDETC, 2016.

C64. De la Fuente, J., Sugar, T. G, Redkar, S., Bates, A. R. "Nonlinear Phase Based Oscillator to Generate and Assist Periodic Motions", ASME International Design, Engineering, Technical Conferences, IDETC, 2016.

C63. Carberry, A., Kellam, N., Brunhaver, S., Sugar, T. & McKenna, A. "An exploratory study of students' empathy toward others following a product archaeology activity", 2015 6th Research in Engineering Education Symposium: Translating Research into Practice, REES 2015. Dublin Institute of Technology

C62. Sugar, T. G., Kerestes, J., "Developing Exoskeletons to Enhance Running Speed," WeRob 2014.

C61. Holgate, M., Sugar, T. G., "Active Compliant Parallel Mechanisms," IDETC 2014.

C60. New, P., Wheeler, C., Sugar, T. G., "Robotic Hopper Using Phase Oscillator Controller," IDETC 2014.

C59. Schroeder, K., Sugar, T. G., Flaven, T., "A Novel Force Sensitive Resistor Wheatstone Bridge for Prosthesis Control," IDETC 2014.

C58. Kerestes, J., Sugar, T. G., Holgate, M., "Adding and Subtracting Energy to Body Motion – Phase Oscillator," IDETC 2014.

C57. Kerestes, J., Sugar, T. G., Flaven, T., Holgate, M., "A Method to Add Energy to Running Gait – PogoSuit," IDETC 2014.

C56. Kerestes, J., Sugar, T. G., "Enhanced Running Using a JetPack," IDETC 2014.

C55. Sugar, T. G., Holgate, M., "Compliant Mechanisms for Robotic Ankles," IDETC 2013.

C54. Ward, J., Sugar, T. G., Hollander, K. W., "Optimizing the Translational Potential Energy of Springs for Prosthetic Systems", MSC 2011.

C53. Sugar, T. G., Hollander, K. W., Hitt, J. K., "Walking with Springs," SPIE, EAPAD, 2011.

C52. Hitt, J., Merlo, J., Boehler, A., Holgate, M., and Sugar, T., "Bionic Running for Unilateral Transtibial Military Amputees," 27<sup>th</sup> Army Science Conference, Orlando, Florida, Nov., 2010.

C51. Hitt, J., Brechue, W., Boehler, A., Ward, J., Hollander, K., Sugar, T., Audet, D., and Kanagaiki, D., "Dismounted Soldier Biomechanical Power Regeneration," 27<sup>th</sup> Army Science Conference, Orlando, Florida, Nov., 2010.

C50. Hitt, J., and Sugar, T., "Load Carriage Effects on a Robotic Transtibial Prosthesis," International Conference on Control, Automation and Systems, Gyeonggi-do, Korea, Oct, 2010.

C49. Jeffrey Ward, T. Sugar, J. Standeven, J. R. Engsberg, "Stroke Survivor Gait Adaption and Performance After Training on a Powered Ankle Foot Orthosis", IEEE International Conference

on Robotics and Automation (ICRA), 2010.

C48. Briner, D., Sardhara, A., Sugar, T., "A Multi-Pin End-Effector for a Robotic Colony Picker," ASME Early Career Technical Conference, Oct 2009.

C47. S. Redkar, T. Sugar, B. Dillard, and K. Narayanan, "Inertial Sensing of Dummy Kinematics," ASME International Design Engineering Technical Conference, CD-ROM, 2009.

C46. M. Holgate, T G. Sugar, A. Boehler, "A Novel Control Algorithm for Wearable Robotics using Phase Plane Invariants, IEEE International Conference on Robotics and Automation (ICRA), 2009.

C45. M. Holgate, J. K. Hitt, R. D. Bellman, T. G. Sugar, K. W. Hollander, "The SPARKy (Spring Ankle with Regenerative Kinetics) Project: Choosing a DC Motor Based Actuation Method," Biorobotics 2008.

C44. R D. Bellman, T. G. Sugar, "SPARKy 3: Design of an Active Robotic Ankle Prosthesis with Two Actuated Degrees of Freedom Using Regenerative Kinetics," Biorobotics 2008.

C43. M. A. Holgate, A. W. Boehler, T. G. Sugar, "Control Algorithms for Ankle Robots: A Reflection on the State-of-the-Art and Presentation of Two Novel Algorithms," Biorobotics 2008.

C42. A. Boehler, K. W. Hollander, T. G. Sugar, D. Shin, "Design, Implementation and Test Results of a Robust Control Method for a Powered Ankle Foot Orthosis (AFO), IEEE International Conference on Robotics and Automation (ICRA), 2008.

C41. Shin, D., Wolf, P., Thomas, Sugar, and Herring, D., *It Takes Two to Tango: Designers and engineers team up to develop an innovative stroke rehabilitation device*, 2nd International Conference on Applied Human Factors and Ergonomics (AHFEI), 2008.

C40. J. Hitt, R. Bellman, M. Holgate, T. Sugar, and K. Hollander, The SPARKy (Spring Ankle with Regenerative Kinetics) Project: Design and Analysis of a Robotic Transtibial Prosthesis with Regenerative Kinetics, ASME International Design Engineering Technical Conference, CD-ROM, pp. 1-10, 2007.

C39. K. Hollander and T. Sugar, "A Robust Control Concept for Robotic Ankle Gait Assistance," IEEE International Conference on Rehabilitation Robotics (ICORR), Holland, 2007.

C38. J. Ward, S. Balusubramanium, and T. Sugar, "Robotic Gait Trainer Reliability and Stroke Patient Case Study," IEEE International Conference on Rehabilitation Robotics (ICORR), Holland, 2007.

C37. A. Mehmet Oymagil, J. Hitt, T. Sugar, and J. Fleeger, "Control of a Regenerative Braking Powered Ankle Foot Orthosis," IEEE International Conference on Rehabilitation Robotics (ICORR), Holland, 2007.

C36. J. Hitt, A. Mehmet Oymagil, T. Sugar, K. Hollander, A. Boehler and J. Fleeger, "Dynamically Controlled Ankle-Foot Orthosis (DCO) with Regenerative Kinetics: Incrementally Attaining User Portability," IEEE International Conference on Robotics and Automation (ICRA), Roma, Italy, 2007.

C35. D. Morrell, R. Grondin, CY. Kuo, C. Roberts, R. Hinks, M. Henderson, T. Sugar, and S. Danielson, "Beyond Measurement: Designing Engineering Outcomes to Foster Student Achievement," 2006 American Society for Engineering Education Annual Conference and Exposition, June 2006.

C34. J. Ward, J. Hitt, T. Sugar, and K. Bharadwaj, "Dynamic Pace Controller for the Robotic Gait Trainer," ASME International Design Engineering Technical Conference, CD-ROM, pp. 1-6, 2006.

*ICRA is accepting only 39% of the submitted conference papers*

C33. Z. Wang, A. Paranjape, T. Sugar, and M. K. McBeath, "Perceptual Navigation Strategy for Mobile Robots Intercepting Ground Balls," IEEE International Conference on Robotics and Automation, pp. 2713-2718, 2006.

C32. K. Bharadwaj and T. G. Sugar, "Kinematics of a robotic gait trainer for stroke rehabilitation," IEEE International Conference on Robotics and Automation, pp. 3492-3497, 2006.

C31. J. He, E. Koeneman, R. Schultz, D. E. Herring, J. Wanberg, H. Huang, T. Sugar, R. Herman, and J. Koeneman, "RUPERT: A Device for Robotic Upper Extremity Repetitive Therapy," 27th IEEE EMBS Annual International Conference, Shanghai, China, September 1-4, 2005.

C30. S. Danielson, M. Henderson, C.Y. Kou, D. Morrell, R. Grondin, R. Hicks, and T. Sugar, "A Clean Slate: Designing A Mechanical Systems Concentration Within A New Engineering Program" Proceedings of IMECE2005, 2005 International Mechanical Engineering Conference and Exposition, Orlando, Florida, USA, November 5-11, 2005.

C29. K. Bharadwaj and T. G. Sugar, "Design of a robotic gait trainer using spring over muscle actuators for ankle stroke rehabilitation," Design of Medical Devices Conference, pp. 1-10, 2005.

C28. K. W. Hollander, R. Ilg, and T. G. Sugar, "Design of the Robotic Tendon," Design of Medical Devices, pp. 1-3, 2005.

C27. K. W. Hollander and T. G. Sugar, "Design of Lead Screw Actuators for Wearable Robotic Applications," ASME International Design Engineering Technical Conference, CD-ROM, pp. 1-10, 2005.

C26. K. W. Hollander, T. G. Sugar, and D. Herring, "A Robotic Jack Spring for Ankle Gait Assistance," ASME International Design Engineering Technical Conference, CD-ROM, pp. 1-10, 2005. 2<sup>nd</sup> Place Finish in the Graduate Student Design Competition

C25. J. He, E. J. Koeneman, R. S. Schultz, D. E. Herring, H. Huang, T. Sugar, R. Herman, and J. B. Koeneman, "Design of a Robotic Upper Extremity Repetitive Therapy Device," 9<sup>th</sup> Annual Conference on Rehabilitation Robotics, ICORR, pp. 95-98, 2005.

C24. K. W. Hollander, T. G. Sugar, and D. Herring, "Adjustable Robotic Tendon using a Jack Spring," IEEE 9<sup>th</sup> Annual Conference on Rehabilitation Robotics, ICORR, pp. 113-118, 2005.

C23. K. Hollander and T. Sugar, "Concepts for Compliant Actuation in Wearable Robotic Systems," presented at U.S. Korea Conference, UKC, August 2004, pp. 1-7, August 2004.

C22. K. Bharadwaj, K. Hollander, C. Mathis, and T. Sugar, "Spring over Muscle (SOM) Actuator for Rehabilitation Devices," 26<sup>th</sup> Annual International Conference of the IEEE EMBS, San Francisco, CA, pp. 2726-2729, 2004.

C21. Z. Wang, K. Hollander, and T. G. Sugar, "A Novel Omni-directional Perturbation Platform," presented at IEEE/RSJ International Conference on Intelligent Robots and Systems, Las Vegas, pp. 3089-3093, 2003.

C20. Z. Wang, K. Bauernfeind, and T. G. Sugar, "Omni-Directional Treadmill System,"

presented at 11th International Symposium on Haptic Interfaces for Virtual Environments and Teleoperator Systems, Los Angeles, pp. 367-373, 2003.

C19. D. Nahar and T. G. Sugar, "Compliant Constant-Force Mechanism with a Variable Output for Micro/Macro Applications," IEEE International Conference on Robotics and Automation, pp. 318-323, 2003.

C18. K. Mundhra, T. G. Sugar, and M. K. McBeath, "Perceptual Navigation Strategy: A Unified Approach to Interception of Ground balls and Fly balls", IEEE International Conference on Robotics and Automation, pp. 3461-3466, 2003.

C17. D. Nahar, T. G. Sugar, and P. Fussell, "Novel, Compliant, Synergistic Interactions of Multiple Contacts for Grasping," presented at World Automation Congress (WAC2002), Florida, CD-ROM proceedings, pp. 1-7, 2002.

C16. A. Suluh, K. Mundhra, T. G. Sugar, and M. McBeath, "Spatial Interception for Mobile Robots," presented at Proceedings of the 2002 IEEE International Conference on Robotics and Automation, Washington D.C., pp. 4263-4268, 2002.

C15. K. Mundhra, A. Suluh, T. G. Sugar, and M. McBeath, "Intercepting a Falling Object: Digital Video Robot," presented at Proceedings of the 2002 IEEE International Conference on Robotics and Automation, Washington D.C., pp. 2060-2065, 2002.

C14. D. Burns and T. G. Sugar, "Rapid Embedded Programming: A Tool for Education," presented at 2002 ASME Design Engineering Technical Conferences and Computers in Engineering Conference, Montreal, CD-ROM, pp. 1-7, 2002.

C13. T. G. Sugar and P. Fussell, "Mouth Operated Neurosurgical Robot," presented at Proceedings of the 2001 ASME Design Engineering Technical Conferences and Computers in Engineering Conference, CD-ROM, 2001.

C12. T. G. Sugar and M. McBeath, "Spatial Navigation Algorithms: Applications to Mobile Robotics," presented at Proceedings of VI 2001 Vision Interface Annual Conference, pp. 106-113, 2001.

C11. A. Suluh, T. G. Sugar, and M. McBeath, "Spatial Navigation Principles: Applications to Mobile Robotics," presented at Proceedings of the 2001 International Conference on Robotics and Automation, pp. 1689-1694, 2001.

C10. T. G. Sugar, J. P. Desai, V. Kumar, and J. Ostrowski, "Coordination of Multiple Mobile Manipulators," presented at Proceedings of the 2001 IEEE International Conference on Robotics and Automation, pp. 3022-3027, 2001.

C9. L. Chaimowicz, T. G. Sugar, V. Kumar, and M. F. M. Campos, "An Architecture for Tightly Coupled Multi-Robot Cooperation," presented at Proceedings of the 2001 IEEE International Conference on Robotics and Automation, pp. 2992-2997, 2001.

C8. T. G. Sugar, "A Novel Selective Compliant Actuator," presented at In the Proceedings of the 7th Mechatronics Forum, Atlanta, pp. CD-ROM, pp. 1-6, 2000.

C7. T. G. Sugar and V. Kumar, "Metrics for Analysis and Optimization of Grasps and Fixtures," presented at Proceedings of the 2000 IEEE International Conference on Robotics and Automation, San Francisco, CA, pp. 3561-3566, 2000.

C6. T. G. Sugar and V. Kumar, "Coordination of Multiple Mobile Platforms for Manipulation and Material Transport," presented at Video Proceedings of the 1999 IEEE International Conference on Robotics and Automation, Detroit, 1999.

C5. T. G. Sugar and V. Kumar, "Multiple Cooperating Mobile Manipulators," presented at Proceedings of the 1999 IEEE International Conference on Robotics and Automation, Detroit, pp. 1538-1543, 1999.

C4. T. G. Sugar and V. Kumar, "Design and control of a compliant parallel manipulator for a mobile platform," presented at Proceedings of the 1998 ASME Design Engineering Technical Conferences and Computers in Engineering Conference, Atlanta, CD-ROM, pp. 1-9, 1998.

C3. T. G. Sugar and V. Kumar, "Decentralized control of cooperating manipulators," presented at Proceedings of the 1998 IEEE International Conference on Robotics and Automation, Belgium, pp. 2916-2921, 1998.

C2. E. Paljug, T. G. Sugar, V. Kumar, and X. Yun, "Important Considerations in Force Control with Applications to Multi-Arm Manipulation," presented at Proceedings of the 1992 IEEE International Conference on Robotics and Automation, pp. 1270-1275, 1992.

C1. G. Pfreundschat, T. G. Sugar, and V. Kumar, "Design and Control of a 3DOF In-Parallel Actuated Manipulator," presented at Proceedings of the 1991 IEEE International Conference on Robotics and Automation, Sacramento, CA, pp. 1659-1664, 1991.

## PUBLICATIONS

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### National Conference Proceedings Reviewed Papers, Abstracts, and Presentations

#### Abstracts in Journals and Books

A12. Aggers, A., Sugar, T. G., Holgate, M., Engsberg, J.R. 2010, Gait Comparison of Passive and Active Terminal Devices for a Person with a Transtibial Amputation (TTA)

A11. DaSilva, F., McBeath, M., Sugar, T. (2007). Stroke Therapy Using Wearable-Robots and Ramachandran Mirror Technique Produces Functional Improvement [Abstract]. *Journal of Vision*.

A10. DaSilva, F., Wechsler, N. E., McBeath, M., Sugar, T., Amazeen, E., Presson, C., & Koeneman, J. (2006). Improvement in upper-extremity motor-function in hemiparetics using robot-assisted repetitive motion therapy with video games [Abstract]. *Journal of Vision*, 6(6), 76a, <http://journalofvision.org/6/6/76/>, doi:10.1167/6.6.76.

A9. McBeath, M.K., Wang, W., Sugar, T.G., Dolgov, I. & Wang, Z. (2005). Pursuers Maintain Linear-Optical-Trajectory when Navigating to Intercept Robots Moving Along Complex Pathways. *Abstracts of the Psychonomic Society*. 10, 46. (Ms. No. 295).

A8. McBeath, M.K., Dolgov, I., & Sugar, T.G. (2005). The axis of an American football leads observers to misjudge where it is headed. *Journal of Vision*. 5(8). 731.  
[<http://www.journalofvision.org/5/8/731>](http://www.journalofvision.org/5/8/731)

A7. McBeath, M.K., Sugar, T.G., & Shaffer, D.M. (2004). Catching things that change direction: Frisbees and bouncing grounders. *Cognitive Science Association for Interdisciplinary Learning Abstracts*. 10. <<http://www.ohsu.edu/csail/prog04.html>>

A6. McBeath, M.K., Sugar, T.G., & Wang, Z. (2004). Baseball fielders utilize a rule of constant cotangent change to navigate to catch ground balls. *Journal of Vision*. 4(8), 157.  
[<http://www.journalofvision.org/4/8/157>](http://www.journalofvision.org/4/8/157)

A5. M. K. McBeath, T. G. Sugar, J. M. Thompson, K. Mundhra, "Catching ground balls: Optical Control Heuristics used by Humans and Robots Support a Unified Fielder Theory," *Journal of*

*Vision*. 3(9), 543. (Ms. No. 543). <<http://www.journalofvision.org/3/9/543>>

A4. M. K. McBeath, T. G. Sugar, S. E. Morgan, C. D. Oberle, K. Mundhra, and A. Suluh, "Human and Robotic Catching of Dropped Balls and Balloons: Fielders Still Try to Make the Image of the Projectile Rise," *Journal of Vision*, vol. 2(7), pp. 434, 2002.

A3. M. K. McBeath, D. M. Shaffer, and T. G. Sugar, "Catching baseball pop flies: Individual differences in aggressiveness and handedness," *Abstracts of the Psychonomic Society*, vol. 7, pp. 103, 2002, (Ms. No. 190).

A2. M. K. McBeath, D. M. Shaffer, S. E. Morgan, and T. G. Sugar, "Lack of Conscious Awareness of How We Navigate to Catch Baseballs," *Toward a Science of Consciousness*, vol. 84, 2002, (Ms. No. 190).

A1. M. K. McBeath, T. G. Sugar, and D. M. Shaffer, "Comparison of active versus passive ball catching control algorithms using robotic simulations [Abstract]," *Journal of Vision*, vol. 1(3), pp. 193a, 2001, DOI 10.1167/1.3.193.

## PUBLICATIONS

### Other Publications

### Patents

Somatosensation device for loss of feeling in the foot, T. Sugar, C. Vignola, 2021.

P13. Passive Exoskeleton for Sit-To-Stand and Stand-To-Sit Transfer, J. Okun, T. Sugar, 12,465,543, 2025.

Hip Exoskeleton for Lifting and Pushing, T. Sugar, K. Hollander, 2020.

Hip Exoskeleton Structure for Lifting and Pushing, T. Sugar, K. Hollander, D. Kinney, W. Brandon Martin, 2020.

Soft Robotic Ankle, S. Amatya, A. S. Lafmejani, S. Poddar, S. Sridar, T. Sugar, P. Polygerinos, 2019

P12. Assistive Device for Patients with Somatosensation Deficiency, L Lopez, L Griffith, R. Parmentier, T. Sugar, S. Sridar, P. Nguyen, US12,220,369 2025.

P11. Soft Hip Extension Device to Aid Hemiparetic Gait, A Ptel, R. Borneman, O. Save, Y. Govada, S. Sridar, P. Nguyen, T. Sugar, US12,076,135, September 2024

Ataxia Reactive Compression Sleeve, Y. Gajendran, J. McMillan, H. Moon, J. Pace, S. Sridar, T. Sugar, P. Nguyen, 2019

P10. Soft Wearable Robotic Device to Treat Plantarflexion Contractures, B Shuch, C. Kulkarni, S. Katarey, H. Dangaich, S. Stridar, Ph. Nguyn, T. Sugar, US11,337,879 B2, May 24, 2022

P9. Systems and Methods for Adding or Subtracting Energy to Body Motion, T. Sugar, J. Kerestes, T. Flaven, M. Holgate, US9308642 B2, April 2016.

P8. Joint Control Systems and Methods Utilizing Muscle Activation Sensing, T. Sugar, T. Flaven, G. Wolf, 2013 provisional application, US9192487 B2, 2015.

P7. Thomas Sugar, Joseph Hitt, Alexander Boehler, Kevin Hollander, Jeffrey Ward, Method and Apparatus for Harvesting Energy from Ankle Motion, provisional patent submitted 5/2011,

US8716877 B2, 2014.

P6. K. Hollander, T. G. Sugar, "Adjustable Stiffness Jack Spring Actuator," patent US US8322695, 2012.

P5. K. Hollander, T. G. Sugar, "Adjustable Stiffness Jack Spring Actuator," patent US 7,992,849, 2011.

T. G. Sugar and M. Carhart, "Spring-Over-Muscle Actuator," provisional patent submitted in April 2003, patent pending in April 2004.

P4. T. G. Sugar and D. Nahar, "Adjustable compliant mechanism," US 7,874,223, 2011

P3. K. Hollander, T. G. Sugar, "Adjustable Stiffness Leaf Spring Actuators," US 7,527,253, 2009.

P2. T. G. Sugar and K. Baurenfeind, "Omni-Directional Treadmill", US 7,399,258, 2008.

P1. T. G. Sugar and S. Yalamanchili, "Centrifuge Test Apparatus for Footwear and Apparel," US 5329807: W. L. Gore and Associates, 1994.

### **Thesis and Dissertation**

T. G. Sugar, "Design and Control of Cooperative Mobile Robotic Systems," in *Mechanical Engineering and Applied Mechanics*: University of Pennsylvania, 1999.

T. G. Sugar, "Design and Control of an In-Parallel Pneumatically-Actuated Manipulator," in *Mechanical Engineering and Applied Mechanics*: University of Pennsylvania, 1992.

### **Poster Sessions:**

Dynamic Walking 2011

Dynamic Walking 2009

Dynamic Walking 2008

Dynamic Walking 2007

### **Guest Editor**

1. Vanderborght, B.; Sugar, T.; Lefeber, D., "Adaptable compliance or variable stiffness for robotic applications [From the Guest Editors]", *IEEE Robotics & Automation Magazine*, vol. 15, Issue: 3, pp 8-9, 2008.

### **Guest paper**

2. Exciting Benefits of Powered Prosthetic Systems, Lt. Col. Joseph K. Hitt, PhD; Kevin Hollander, PhD; and Thomas Sugar, PhD, The O&P EDGE, October 2010

### **Highlight paper**

S. Mohammed *et al.*, "Wearable Robotics for Motion Assistance and Rehabilitation [TC Spotlight]," in *IEEE Robotics & Automation Magazine*, vol. 25, no. 1, pp. 19-28, March 2018. doi: 10.1109/MRA.2017.2787222

## **INVITED PRESENTATIONS**

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DFCon2023, Anaheim, CA, Next Generation Exoskeletons, 23rd Edition of the Interdisciplinary Global Diabetic Foot Conference

Invited speaker at the 2<sup>nd</sup> Shanghai International Symposium on Human Centered Robotics, 7/15/2018

Summer school speaker at HUST University, China, 7/9/2018

“Exoskeletons & Augmentation Systems Present and Emerging Technology and Applications,” ASIO conference, 6/23/2017

“Wearable Robotics,” Vanderbilt University, 1/20/17

“Wearable Robotics,” Clemson University, 1/13/17

**Keynote Speaker** for the FIPRC Fluid Power conference, October 11, 2016 “Wearable Robotics”

Material Handling and Logistics Conference, “Wearable Robotics in the DC”, September 13, 2016

OPT World Congress, Leipzig, Germany, “Powered Bionic Ankles for Highly Active Users,” May 2016

SATEC 16, Sino-American Technology and Engineering Conference, “Wearable Robotics,” May 15, 2016

The University of Texas Austin, January 2016, “Compliant Wearable Robotics”

ICWSR 2015, Zhejiang University, October 2015, “Compliant Wearable Robotics”

DFCon, Los Angeles, March 2015, “R2Flow2 and C3PToe: Here Come the Wearable Robots”

APT Center and FES Center at the Cleveland Veterans Affairs and Case Western University invited talk on “Designing Spring Based Robots for Enhancing Mobility”, February 2013

Leipzig, Germany, ORTHOPÄDIE + REHA-TECHNIK in May 2012

Stuttgart, Germany, Fraunhofer, Institute, Dr. med. Urs Schneider, May 2012

Rio Verde Valley Speaker Series, January 2012

Northern Arizona University invited talk with Kissa Nishikawa October 21, 2011

Invited talk on robot actuators, DARPA November 2011

Dynamic Walking 2011, one of four keynote talks

**Keynote Speaker** for the SPIE EAPAD conference, March 7, 2011 “Walking with Springs”

**Keynote Speaker**, Darmstadt, Germany: Proceedings of SIMPAR 2010 Workshops, Intl. Conf. on SIMULATION, MODELING and PROGRAMMING for AUTONOMOUS ROBOTS Darmstadt (Germany) November 15-16, 2010

SPARKy Phase 2, United States Military Academy at West Point, February 26, 2010.

“Robots: The Interactive Exhibition”, Arizona Science Center, Phoenix, Arizona, March 16, 2006.

Rehabilitation Robotics: Wearable Robotic Systems, Invited Speaker, Symposium on Robotics Technology, U.S. Korea conference, August 13, 2004.

Compliant Actuation, November 7, 2003, Northern Arizona University

Fall Prevention using an Omni-Directional Treadmill, October 2003, Arizona Parkinson Disease Meeting

Human Navigational Principles: Applications to Mobile Robotics, July 7, 2000, University of Pennsylvania

Mobile Robot Cooperation, October 1999, Psychology Department, Arizona State University

## **Research Grants**

### **a. Sponsored Research – External Grants**

#### **Funded Grants**

	<u>Title</u>	<u>Grant</u>	<u>Investigators</u>	<u>Amount</u>
1. NSF PFI Grant, 2017	PFI:BIC ASPIRE: hierArchical control of a Smart ankle-foot Prosthesis that supports Increased mobility for REal-life activities	\$1,000,000	<b>Co-PI:</b> T. Sugar (15%)	\$150,000
2. DOD, 2017	Passive SPARKy-P Prostheses (Spring Ankle with Regenerative Kinetics)	\$150,000	<b>Co-PI:</b> T. Sugar	
3. DOD, 2017	Wireless IMU Sensing for Activity Control of Ankle Prosthesis	\$150,000	<b>Co-PI:</b> T. Sugar	
4. Air Force 2019	Loadmaster Exoskeleton for Aerial Port Delivery	\$1,230,963	<b>PI:</b> T. Sugar	\$1,230,963
5. Kaiteki, 2020	Wearable Hybrid Robotic Suit for Self Actualization	\$232,000 Direct Cost	<b>Co-PI:</b> T. Sugar	\$41,760
6. DOD, 2020	Myoelectrically-Controlled Power-Assist Upper-Extremity Exoskeleton	\$608,038	<b>PI:</b> T. Sugar	\$608,038
7. DOL 2020	Arizona Workforce Training Accelerator Partnership for Next Generation Jobs (AZNext)	\$8,029,594	<b>Co-PI:</b> T. Sugar	\$1,284,735
8. DOD, 2024	Troop Hauler		<b>Co-PI:</b> T. Sugar	
<b>Total</b>		<b>\$11,400,595</b>		<b>\$3,315,496</b>

	<u>Title</u>	<u>Grant</u>	<u>Investigators</u>	<u>Amount</u>
1. DARPA	Four Minute Mile Running (4MM)  Start in the Summer of 2012 for one year	\$131,264	<b>PI:</b> T. Sugar (100%)	\$131,264
2. DARPA	Follow on grant for 2013	\$72,812	<b>PI:</b> T. Sugar	\$72,812
3. DARPA	Four Minute Mile Running (4MM) Year 2 grant for 2014	\$266,004	<b>PI:</b> T. Sugar (50%)	\$133,002
4. DARPA	Hip Exoskeleton for Superior Performance	\$296,523	<b>PI:</b> T. Sugar (50%)	\$148,262
<b>Total</b>		<b>\$766,603</b>		<b>\$485,340</b>

	<u>Title</u>	<u>Grant</u>	<u>Investigators</u>	<u>Amount</u>
5. Army TATRC Walter Reed Army Hospital	SPARKy, Spring Ankle with Regenerative Kinematics, <b>Principal Investigator</b>  1/1/2007 – 8/1/10	\$605,000	<b>PI:</b> T. Sugar (100%)	\$605,000
6. NIH	Robotic Spring Ankle for Gait Assistance, <b>Principal Investigator, Score 139</b>  8/16/05 – 4/15/10	\$359,000	<b>PI:</b> T. Sugar (60%) D Herring (40%)	\$215,400
7. NIH	Contract Extension: Portable and Economical Robots for Stroke Rehabilitation  9/30/06 – 9/29/09	\$1,751,401	J. He D Herring T. Sugar (20%)	\$350,280
8. Army-STTR	Neuromorphic Control of an Ankle  6/2004-12/2004	\$100,000	Prime: Advensys T. Sugar (40% of 31,515)	\$12,606
9. NSF	An Interdisciplinary Research Environment for Motion Analysis,  Collaborative Research with Arts, Media, and Engineering  9/1/06 – 8/31/09	\$1,061,306	T. Sugar (3%)	\$31,839
10. NIH	SBIR: Air Muscle Device for Ankle Stroke Rehabilitation  5/01/04 – 4/30/06	\$200,000	Prime: Kinetic Muscles Inc. T. Sugar (10%)	\$20,000
11. NIH	Contract: Portable and Economical Robots for Stroke Rehabilitation  9/30/03 – 9/29/06	\$2,279,487	J. He D Herring T. Sugar (20%)	\$455,897
12. NSF	SGER: Compliant Actuation for Human Interaction  8/15/03 – 7/31/04	\$52,361	<b>PI:</b> T. Sugar, 100%	\$52,361
13. NSF	Perceptual Invariants as a General Mechanism for Human Interception  8/01/03 – 7/31/06	\$349,995	M. McBeath T. Sugar (50%)	\$174,998
14. NSF	Development of a Interactive Systems and Controls E-Book	\$307,910	T. Rodriguez T. Sugar (10%)	\$30,791

	2/15/03 – 1/31/06			
15. Honeywel l, Inc.	Embedded Control Code using Matlab's xPC Target  1/1/02 – 12/30/02	\$20,000	PI: T. Sugar, 100%	\$20,000
16. HYI	Service Agreement: Manufacturing Composites  7/02 – Present	\$10,033	PI: T. Sugar, 100%	\$10,033
<b>TOTAL</b>		<b>\$7,096,493</b>		<b>\$1,979,205</b>

## RESEARCH GRANTS

### b. Sponsored Research – Internal Grants

	<u>Title</u>		<u>Investigators</u>	<u>Amount</u>
1. ASU Faculty Grant-in-Aid	Human Interfaces for Robotic Systems 1/1/00 - 12/31/00	F-009-00	T. Sugar	\$7,000
2. ASU Research Incentive Award	Dynamic Manipulation with Heterogeneous Partners 6/1/00-5/31/01	274-00	T. Sugar	\$16,000

## SPRINGACTIVE, INC (2008-11/2019)

### c. Robotics Company

SpringActive, Inc was started to develop the patented technology returned to Drs. Sugar and Hollander. The company is developing wearable robotic systems

[www.springactive.com](http://www.springactive.com)

10 full time employees

Dr. Kevin Hollander, Dr. Jeffrey Ward, Dr. Matthew Holgate, Mr. Alex Boehler

### Grants

1. Energy harvesting ankle phase 1 and phase 2 with NATICK
2. Jack Spring grant, NSF SBIR Phase 1 and Phase 2
3. Research an exoskeleton with British Aerospace Engineering, Tempe, AZ
4. Develop force feedback for helicopter seating, SAFE Engineering
5. JTAR, Joint Torque Augmentation, DARPA exploratory research grant
6. Running ankle, NIH SBIR Phase 1
7. Develop a running ankle with USMA
8. Develop a wearable exoskeleton with USMA
9. Develop a controller for the West Point Bionic Ankle

Products  
Hermes ankle, Odyssey ankle, ROLLE exoskeleton

## STUDENT THESES AND DISSERTATIONS ADVISED

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### THESIS ADVISOR

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#### (M.S. STUDENTS) - 22

Anthony Suluh	Mechanical Engineering	Graduated Dec. 2001.
Thesis: Human Navigational Principles: Applications to Mobile Robotics		
Keshav Munhdra	Mechanical Engineering	Graduated Dec. 2002.
Thesis: Perceptual Guidance Strategies Applied to High-Speed Mobile Robots		
Dhiraj Nahar	Mechanical Engineering	Graduated Dec. 2002.
Thesis: Analysis and Synthesis of Passive Compliant Mechanisms		
Kiran Shivanna	Mechanical Engineering	Graduated Aug. 2003.
Thesis: Sensitivity Analysis of Cracks in Functionally Graded Materials		
Zheng Wang	Mechanical Engineering	Graduated Aug. 2003.
Thesis: Design of an Omni-Directional Perturbation Platform with Powered Offset Casters		
Kartik Bharadwaj	Mechanical Engineering	Graduated Dec. 2005.
Thesis: Design and Control of a Robotic Gait Trainer Using Spring over Muscle Actuators for Stroke Rehabilitation of the Ankle Joint		
Chitralekha Nahar	Mechanical Engineering	Graduated Dec. 2005.
Thesis: Evaluation and Control of an Omni-Directional Perturbation Platform for Balance Studies		
Abhay Paranjape	Mechanical Engineering	Graduated May. 2006.
Thesis: Perceptual Navigation Strategies for Mobile Robots Intercepting Ground Balls		
Sukumar Srikant	Mechanical Engineering	Graduated Aug. 2006.
Thesis: System Identification and Inertia Compensated Control of a Planar Manipulator		
Aykut Mehmet Oymagil	Mechanical Engineering	Graduated Dec. 2006.
Thesis: Control of a Regenerative Braking Powered Ankle Foot Orthosis		
Jeffrey A. Ward	Mechanical Engineering	Graduated May 2007.
Thesis: Dynamic Pace Controller for the Robotic Gait Trainer and Stroke Patient Case Study		
Don Briner	Mechanical Engineering	Graduated May 2008.
A Pick Selection Algorithm for a Machine Vision Guided Robotic Colony Picker		
Alex Boehler	Mechanical Engineering	Graduated May 2008.
Mechanics, Control and Testing of a Robotic Ankle Foot Orthosis for Stroke Rehabilitation		
Ryan Bellman	Mechanical Engineering	Graduated August 2008.
Mechanical and Conceptual Design of a Robotic Transtibial Prosthesis		
Ashish Sardhara	Mechanical Engineering	Graduated August 2009.
Design and Testing of Multi-Pin End-Effector for a Robotic Colony Picker		
Adam Fronczyk	Biomedical Engineering <b>Co-Chair</b>	Graduated August 2012.
Volitional Control of a Powered Prosthetic Ankle		

Chase Wheeler	Mechanical Engineering	Graduated December 2014.
Load Carrying Assistance Device: PogoSuit		
Jason Kerestes	Mechanical Engineering	Graduated December 2014.
Robotic Augmentation of Human Locomotion for High Speed Running		
Andrew Bates	Mechanical Engineering	Graduated May 2015.
Phase Oscillator		
Philip New	Mechanical Engineering	Graduated May 2015.
Using the Phase Angle Oscillator Controller for Hopping Robots		
Raymond Churchwell	Engineering	Graduated May. 2020.
A Study on the Use of Extrusion-based Additive Manufacturing for Electrostatic Discharge		
Compliant Components from PEEK-Carbon Nanotube Composite		
Bryan Carlton	Robotics and Autonomous Systems	Graduated May. 2023.
Upper Extremity Exoskeleton		

#### **Co-Advisor (1):**

Aniket Chitale	Mechanical Engineering	Graduated August 2018.
Generalized T-Map Modelling Procedure & Tolerance Sensitivity Analysis using T-Maps		

#### **(Ph.D. STUDENTS) – 7, 4 = 11**

Zheng Wang	Mechanical Engineering	Graduated Dec. 2005.
Dissertation: Theory for a Mobile Robot Intercepting Projectiles Above and Below the Horizon		
Kevin Hollander	Mechanical Engineering	Graduated Dec. 2005.
Dissertation: Design and Control of Wearable Robot Actuators		
Joseph Hitt	Mechanical Engineering	Graduated May. 2008.
Dissertation: A Robotic Transtibial Prosthesis with Regenerative Kinetics		
Jeffrey Ward	Mechanical Engineering	Graduated Dec. 2009.
Dissertation: Design, Control, and Data Analysis for Rehabilitation Robotics		
2010 ASEE/NSF Corporate Research Postdoctoral Fellowship for Engineers		
W. Brandon Martin	Systems Engineering	Graduated Dec. 2021.
Dissertation: Development of an Aerial Porter Exoskeleton and Exoskeleton Standardization Metrics		
Alex Boehler	Systems Engineering	Graduated Dec. 2021.
Dissertation: Advanced Control Systems for Exo-skeletons		
Claudio Vignola	Systems Engineering	Graduated Dec. 2023.
Dissertation: Embodied Wearables: The Role of Proprioception in Exoskeleton Design		

#### **Co-Advisor (4):**

Matthew Holgate	Mechanical Engineering	Graduated Dec. 2009.
Dissertation: Control of a Robotic Transtibial Prosthesis		
2010 ASEE/NSF Corporate Research Postdoctoral Fellowship for Engineers		
Juan Oziel De la Fuente Valadez	Mechanical Engineering	Graduated Dec. 2016.

Dissertation: Nonlinear Phase Based Control to Generate and Assist Oscillatory Motion with Wearable Robotics

Nathan Cahill	Mechanical Engineering	Graduated Aug. 2017.
Dissertation: Optimal Design Methods for Increasing Power Performance of Multiactuator Robotic Limbs		
Robert Holgate	Mechanical Engineering	Graduated Aug 2017.
Dissertation: Advanced Prosthetics and Joint Mechanisms		

**(M.S.E. STUDENTS) - 2**

Xiao Zhang	Mechanical Engineering	Graduated Dec. 2005.
Bekele Atnafu	Mechanical Engineering	Graduated Dec. 2005.

**(MS Applied Project Students) - 6**

Anthony Rico	Engineering	Graduated Dec. 2019.
Aundre Garcia	Engineering	Graduated May. 2020.
Connor Giam	Engineering	Graduated May. 2020.
Gustin Lighthouse	Engineering	Graduated May. 2020.
Claudio Vignola	Engineering	Graduated May. 2020.
Gerard Fusaro	Engineering	Graduated May. 2022.

**Current Students are Numbered**

1. Jake Okun, Honors Student

**Exchange students from Austria**

Kurt Baurenfeind	Mechanical Engineering	Exchange Student.
Christian Mathis	Mechanical Engineering	Exchange Student.
Robert Ilg	Mechanical Engineering	Exchange Student.
Alexander Boehler	Mechanical Engineering	Exchange Student.
Lukas Fink	Mechanical Engineering	Exchange Student.
Sebastian Bereuter	Engineering	Exchange Student.
Philipp Pasolli	Engineering	Exchange Student.

**Exchange students from France**

Cathia Lize	Mechanical Engineering	Exchange Student.
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**ADVISOR FOR UNDERGRADUATE RESEARCH**

Jennifer Fleeger (supported honors student for 2004, 2005, 2006 FURI)

Ryan Bellman (honors thesis) (supported honors student for 2004, 2005, 2006 FURI)

Ryan Manis (supported honors student for 2008)

Arizona State Univ.

Nathan Cahill      Mechanical Engineering      Arizona State Univ.  
**NSF Graduate Fellowship Award for Year 2014**

Raymond Churchwell      Mechanical Engineering      Arizona State Univ.  
**NSF Honorable Mention for the Graduate Fellowship Award for Year 2015**

## FURI Students

1. Kyle Lewis Spring 2018, Fall 2018
2. James Lyon Spring 2018, Fall 2018
3. Brian Burca Fall 2018
4. Jake Okun Spring 2022, Fall 2022

## Barrett Honors Students

1. Daniel Burns, NSF Graduate Fellowship Award for Year 2002
2. Thomas Bowers
3. Ethan Stump
4. Nicholas Brindley, NSF Honorable Mention for the Graduate Fellowship in 2003
5. Ryan Bellman
6. Andrew Bates
7. Tanguy Toulouse
8. Kenny Greason
9. Curtis Sparks
10. Kyle Lewis
11. Brian Burca, Drop Foot Rehabilitation, 2020
12. Nicholas Riley, Personalized Transtibial Prosthesis Aesthetic Cover, 2021
13. Gerard Fusaro, Personalized Transtibial Prosthesis Aesthetic Cover, 2021
14. Jacob Yoshitake, 2021, Investigating the Effects of Geometry Shapes on FDM Printing Overhangs Without Support
15. Bryan Carlton, Upper Extremity Exoskeleton, 2022
16. Reagen Gillespie
17. Jake Okun, Rise Exoskeleton, 2023
18. Tallin Speek
19. Tyler Hayes
20. Todd Hayes
21. Alexander Wada
22. Yumi Toulegenova

## UNDERGRADUATE HONOR'S PROGRAM

Daniel Burns (honor's thesis)   Mechanical Engineering  
**NSF Graduate Fellowship Award for Year 2002**

Arizona State Univ.

Thomas Bowers (honor's thesis) Mechanical Engineering

Arizona State Univ.

Ethan Stump (honor's thesis)	Mechanical Engineering	Arizona State Univ.
Nicholas Brindley (honor's thesis)	Mechanical Engineering	Arizona State Univ.
<b>NSF Honorable Mention for the Graduate Fellowship in 2003</b>		
Ryan Bellman (honor's thesis, supported honors student for 2005, 2006, 2007)		Arizona State Univ.
Andrew Bates (honor's thesis, supported honors student for 2011-2012)		Arizona State Univ.
Tanguy Toulouse (honor's thesis, 2017)		Arizona State Univ.
Kenny Greason (honor's thesis, 2017)		Arizona State Univ.
Curtis Sparks (honor's thesis, May 2019)		Arizona State Univ.
Kyle Lewis (honor's thesis, May 2019)		Arizona State Univ.
Brian Burca (honor's thesis, May 2020)		Arizona State Univ.
Nicholas Riley (honor's thesis, April 2021)		Arizona State Univ.
Gerard Fusaro (honor's thesis, April 2021)		Arizona State Univ.
Jacob Yoshitake (honor's thesis, December 2021)		Arizona State Univ.
Bryan Carlton (honor's thesis, May 2022)		Arizona State Univ.
Tallin Speek (honor's thesis, May 2023)		Arizona State Univ.
Reagen Gillespie (honor's thesis, May 2023)		Arizona State Univ.
Jake Okun (honor's thesis, December 2023)		Arizona State Univ.
Tyler Hayes (honor's thesis, May 2025)		Arizona State Univ.
Todd Hayes (honor's thesis, May 2025)		Arizona State Univ.
Alexander Wada (honor's thesis, May 2025)		Arizona State Univ.
Yumi Toulegenova (honor's thesis, May 2025)		Arizona State Univ.

## CURRENT RESEARCH

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### 1. Physical Therapy Assist Device – Medical Robots

In conjunction with the bioengineering department, Kinetic Muscles Inc, and Banner Health, a therapy assist device is being developed which will aid stroke patients in neural re-training using a wearable robotic exoskeleton. The device will assist upper arm movements for feeding and reaching. RUPERT – Robotic Upper Extremity Repetitive Training

### 2. Wearable Robotic Exoskeletons – Medical Robots

Compliant actuation systems are designed to safely interact with humans. These actuators, tunable leaf springs, springs-over-muscles, and jack-springs, are lightweight, energy efficient, power reducing, and safe. They will be used in areas such as stroke rehabilitation, physical rehabilitation, muscle assistance, and gait training.

### 3. Human Navigational Principles

Collaboration with Psychology to develop models for human navigational and pursuit strategies. Research the unconscious, low-level motor vision algorithms used by humans. A mobile robot is designed as a test-bed.

### 4. SPARKy – Medical Robots

A powered bionic ankle is being developed for the Military Amputee Research Program. The powered ankle stores energy in springs as the leg rolls over the ankle and releases the energy in a powerful burst for push-off. SPARKy (SPring Ankle with Regenerative

Kinetics) allows a person to walk with improved gait symmetry and normal push-off power.

#### 5. Powered Ankle Foot Orthosis – Medical Robots

A powered ankle foot orthosis is being developed for the National Institutes of Health. The powered orthosis stores energy in springs as the leg rolls over the ankle and releases the energy in a powerful burst for push-off. The repetitive training paradigm is being used to assist stroke survivors who are paralyzed on one side.

#### 6. Embedded Computing for Education

Motor control labs are developed which allow the user to automatically generate, real-time, embedded code for PC's. Examples include a compliant joystick and an active suspension which dynamically adjusts the equilibrium position of the suspension.

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### 6. DEVICE DEVELOPMENT

#### 1. Spring Over Muscle Actuator

Actuator Designed for a stroke therapy device.

#### 2. Adjustable Constant Force mechanism

Device for gravity compensation of stroke affected limbs.

#### 3. Sit-To-Stand Device - Leaf Spring Actuators

Device for aiding people to stand from a sitting position.

#### 4. Stroke Therapy Devices

Upper Extremity Robot, Ankle Robot for Gait Training, RUPERT

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### 7. RESEARCH COLLABORATIONS:

#### 1. Kinetic Muscles Inc. – Dr. James Koeneman

Local robotics company developing devices for stroke rehabilitation

#### 2. Good Samaritan Hospital – Dr. Richard Herman

Clinical trials of the robotic exoskeletons used in stroke rehabilitation

#### 3. Northern Arizona University – Dr. Kissa Nishikawa

Develop models for human muscle

#### 4. Fachhochschule Vorarlberg – Dr. Robert Merz

Robotics exchange students

#### 5. Dr. Just Herder, Delft University – expert in storage of energy in spring systems

#### 6. Dr. Jack Engsberg, Human Performance Laboratory, Washington University at St. Louis

#### 7. Dr. Alain Berthoz – College de France

## TEACHING AND INSTRUCTION

### 1. Classroom Effectiveness

#### Courses Taught and Student Evaluations

<u>Year and Term</u>	<u>Class #</u>	<u>Title</u>	<u>No. Students</u>	<u>Evaluation Avg.</u> (Fulton School of Engineering Average, MAE Average)
1999 Fall	MAE 341	Design of Machinery	35	<b>4.36/5.0</b> (4.20,4.08)
2001 Fall			37	<b>4.01/5.0</b> (4.17,4.18)
2003 Spring			41	<b>4.62/5.0</b> (4.10,4.24)
2000 Fall	ECE 100	Introduction to Engineering	80	<b>3.91/5.0</b> (3.92,4.21)
2002 Spring	ECE 194		43	<b>4.32/5.0</b> (4.15,4.11)
2000 Spring	MAE 442/591E	Mechanical Systems Design	20	<b>4.19/5.0</b> (4.33,4.24)
2001 Spring	MAE 442		18	<b>4.53/5.0</b> (4.22,4.19)
2002 Fall	MAE 442		20	<b>4.47/5.0</b> (4.14,4.10)
2003 Fall	MAE 442		26	<b>4.44/5.0</b> (4.11,3.92)
2004 Fall	MAE 442		33	<b>4.65/5.0</b>
2002 Spring	MAE 547	Mechanical Design and Control of Robots	9	<b>4.79/5.0</b> (4.54,4.11)
2004 Spring			11	<b>4.54/5.0</b> (4.45,4.06)
2005 Fall			12	<b>4.58/5.0</b>

2003 Fall	MAE 443	Capstone Engineering Design	46	<b>4.24/5.0</b> (4.11,3.92)
2005 Spring			43	<b>3.66/5.0</b>
2005 Spring	IEEE 463	Computer Aided Manufacturing and Control	56	<b>4.13/5.0</b>
2006 Spring			56	<b>3.98/5.0</b>
2006 Summer	MAE Senior Proj	Sponsored a summer student		

Student Evaluations at the Department of Engineering, ASU Polytechnic Campus

<u>Year and Term</u>	<u>Class #</u>	<u>Title</u>	<u>No. Students</u>	<u>Evaluation Avg.</u>
2005 Fall	EGR 194	Engineering 1	28	
2006 Spring	EGR 194	Engineering II, Dynamics Module	26	<b>4.32/5.0</b>
2006 Fall	EGR 294	Engineering Project 1	25	<b>4.41/5.0</b>
2007 Spring	EGR 102	Intro to Engineering Design II	25	<b>4.47/5.0</b>
	MAE 547	Mechanical Design and Control of Robots	12	<b>4.48/5.0</b>
2007 Fall	EGR 301	Engineering Primary Project 1	17	<b>4.47/5.0</b>
	EGR 394	Failure Prevention Module	8	<b>4.39/5.0</b>
2008 Spring	EGR 202	Engineering Project 2	27	<b>4.57/5.0</b>
	EGR 231	Dynamics Module	20	<b>3.94/5.0</b>
	EGR 394	Engineering Design	9	<b>4.50/5.0</b>
2008 Fall	Sabbatical			
2009 Spring	EGR 445	Mechanical Engineering Systems	12	<b>3.70/5.0</b>
	EGR 202	Engineering Project 2	44	<b>3.92/5.0</b>
2009 Fall	EGR 346	Engineering Design	14	<b>4.87/5.0</b>
	EGR 401	Senior Project Medtronic Pressure Sensor Honeywell Clutch Project	13	
2010 Spring	EGR 445	Mechanical Engineering Systems	11	<b>4.73/5.0</b>

	EGR 402	Senior Project Medtronic Pressure Sensor Honeywell Clutch	13	<b>4.83/5.0</b>
2010 Fall	EGR 346	Engineering Design	22	<b>4.44/5.0</b>
	EGR 394	Robotics 1	9	<b>4.35/5.0</b>
	EGR 401	Senior Project Sandia National Labs	6	
2011 Spring	EGR 445	Mechanical Engineering Systems	22	<b>4.60/5.0</b>
	EGR 494	Robotics 2	8	<b>4.17/5.0</b>
	EGR 402	Senior Project Sandia National Labs	6	<b>DEPT AVG 3.65</b>
2011 Fall	EGR 346	Engineering Design	15	<b>5.0/5.0</b>
	EGR 394	Robotics 1	25	<b>4.80/5.0</b>
	EGR 401	Senior Project Sandia National Labs AFSOR Climbing	12	<b>DEPT AVG 3.84</b>
2012 Spring	EGR 445	Mechanical Engineering Systems	20	<b>4.6/5.0</b>
	EGR 494	Robotics 2	16	<b>4.7/5.0</b>
	EGR 402	Senior Project Sandia National Labs AFSOR Climbing	11	
	EGR 401	Senior Project Intel Heater Testbed	4	
	EGR499	Independent Study/ Robotics 3	5	<b>5.0/5.0</b>
	HON	Honors Student	1	
2012 Fall	EGR 346	Engineering Design	25	<b>4.3/5.0</b>
	EGR 401	Senior Project Sandia National Labs AFSOR Climbing	5	
2013 Spring	EGR 445	Mechanical Engineering Systems	41	<b>4.48/5.0 AVG of scores</b>
2013 Fall	EGR 201	Project Course	39	<b>4.12/5.0 AVG</b>

	EGR 520	Engineering Systems Design	15	<b>of scores</b> <b>4.91/5.0 AVG of scores</b>
2014 Spring	EGR 445	Mechanical Engineering Systems	33	<b>4.56/5.0 AVG of scores</b>
	MAE 547	Mechanical Design and Control of Robots		<b>4.36/5.0 AVG of scores</b>
2014 Fall	EGR 201	Project Course	41	<b>3.79/5.0 AVG of scores</b>
2015 Spring	EGR 445	Mechanical Engineering Systems	47	<b>4.20/5.0 Avg. of scores</b>
2016 Fall	EGR 444	Engineering Design	103	<b>3.58/5.0 Avg of scores</b>
2017 Spring	EGR 444	Engineering Design	16	<b>4.81/5.0 Avg of scores</b>
2017 Fall	EGR 444	Engineering Design	59	<b>4.42/5.0 Avg of scores</b>
2018 Spring	EGR 444	Engineering Design	31	<b>4.77/5.0 Avg of scores</b>
2018 Fall	EGR 444	Engineering Design	51	<b>4.81/5.0 Avg of scores</b>
	ASU 101		19	<b>4.33/5.0 Avg of scores</b>
2019 Spring	EGR 444	Engineering Design		<b>4.57/5.0 Avg of scores</b>
	EGR 598	Mechatronics and Device Innovation		<b>4.59/5.0 Avg of scores</b>
2019 Fall	EGR 550	Mechatronic Systems	27	<b>4.38/5.0 Avg of scores</b>
2020 Spring	EGR 608	Advanced Simulation	10	<b>4.81/5.0 Avg of scores</b>
2020 Fall	EGR 550	Mechatronic Systems	36	<b>4.69/5.0 Avg of scores</b>
2021 Spring	EGR 608	Advanced Simulation	13	<b>4.44/5.0 Avg of scores</b>
2021 Fall	EGR 550	Mechatronic Systems	44	<b>4.20/5.0 Avg of scores</b>
2022 Spring	EGR 608	Advanced Simulation	10	<b>4.65/5.0 Avg of scores</b>
2022 Fall	EGR 550	Mechatronic Systems	48	<b>4.71/5.0 Avg of scores</b>
2023 Spring	EGR 445	Mechanical Engineering Systems	73	<b>3.84/5.0 Avg of scores</b>

2023 Fall	EGR 550	Mechatronic Systems	58	<b>4.70/5.0 Avg of scores</b>
2024 Spring	EGR 443/ EGR598	Transforms and System Modeling	47	<b>4.47/5.0 Avg</b> <b>4.67/5.0 Avg</b>
2024 Fall	EGR 550	Mechatronic Systems	98	<b>4.85/5.0 Avg</b>
2025 Spring	EGR 443/ EGR598	Transforms and System Modeling	57/3	<b>4.73/5.0 Avg</b> <b>4.93/5.0 Avg</b>
2025 Fall	EGR 550	Mechatronic Systems	81	<b>4.87/5.0 Avg</b>

## **2. COURSE MATERIAL DEVELOPED**

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### **EGR 102: ENGINEERING II**

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Developed a dynamics module for the class.

### **EGR 201: ENGINEERING STUDIO I**

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Developed a robotic based project for the class. The class is integrated with a manufacturing processes module and a materials module.

### **EGR 301: PRIMARY PROJECT I**

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Developed a thermodynamics project based on a water purification device needed for Africa. The class is integrated with a failure prevention module.

### **EGR 394: FAILURE PREVENTION MODULE**

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Developed a failure prevention module studying tension, compression, bending, torsion, buckling, creep, and hoop stress

### **EGR 346: ENGINEERING DESIGN**

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Developed a machine design course focusing on failure prevention.

### **EGR 445\ MAE 442 \ MAE 591E: MECHANICAL ENGINEERING SYSTEMS**

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1. Motor Control laboratory in Electro Mechanical Laboratory using Real Time Workshop Computers, motors, digital i/o boards, compiler, and Matlab
2. Project based course, Haptic Joystick, Active Suspension of a Vehicle, Mouth Joystick, Robotic Treadmill
3. Equipment proposal for Signal Analyzer

### **ECE 194**

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1. Paper design for a Solar Hot Water Heater for Arizona homes
2. Autonomous robot project

## **MAE 547: MECHANICAL DESIGN AND CONTROL OF ROBOTS**

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1. Design and construction of an autonomous R/C car

## **EGR: ROBOTICS FOCUS AREA**

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Developed a robotics curriculum for the Department of Engineering

### **EGR 394: ROBOTICS 1**

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Developed a robotics course focusing on kinematics and dynamics

### **EGR 394: ROBOTICS 2**

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Developed a robotics course focusing on electronic hardware and controls

## **3. TEACHING: SUPERVISED UNDERGRADUATE PROJECTS**

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### **POLYTECHNIC: SENIOR DESIGN PROJECTS**

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Exoskeleton device for material handling: Los Alamos National Laboratory

### **MAE 490: SENIOR DESIGN PROJECTS**

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Medical Robotic End-effector Development, 1999

Electro-Mechanical System for Discrete Event Machine, Heather Skaar, Erik Johnson 1999

No-Hands Operation of Surgical Robot, Kyle Post, 2000

Robust Enclosure for a Computer Controlled Robot, Alfredo Rodriguez, 2000

Design and Implementation of an Open Loop Hovercraft Controller, Dan Burns, 2001

Design of a Mechanical Process for Automated Fiber Placement in a Thermoplastic, Aaron Shaw, 2001

Determine Roll Center Height Using a Kinematics and Compliant Machine, Shan G. Smith, 2002

Design and Control of a Robotic Treadmill, Andras Dombovari, Ethan Stump, Nicholas Brindley, 2003

Raytheon Missile Project, Jennifer Bayer, Amy Norris, Ryan Barnes, Joshua Green, 2003

Variable Pitch Planetary CVT, Brian Cosner, 2003

Slat Treadmill, Glen Joralmont, Kevin Wolford, 2003

Underwater Robot, Loren Aragon, Marwan, 2004

Raytheon Tail Fin Project, Jasmine Chow, Jennifer, John Herzberger, Jonathan Hoof, 2004

Serial Robot, Ron Newcomb, 2004

### **2<sup>nd</sup> Place, ASME Undergraduate Design Competition, 2004**

Compliant knee actuator, Eric Carter, Mark Carson, 2004

Underwater Robot, Pamela Brady, Marnel McElwain, John Thompson, 2004

Scooter Protective Cover, Kurt S. Allen, Othman Mjahed, 2004

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### **EGR 401/402: SENIOR DESIGN PROJECTS**

**Each Project is Sponsored by \$20,000 per year from the industrial partner**

MEMS pressure sensor: Sponsor Medtronic, 2009-2010

Clutch engagement system: Sponsor Honeywell, 2009-2010

MEMS Accelerometer: Sandia National Labs, 2010-2011, 2011-2012

Intel Heater Test-bed, 2012

AFSOR Climbing Assist Device, 2011-2012, Spiderman Project

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### **UNDERGRADUATE PROJECTS**

Raytheon Design Competition, 2003-2004, 2004-2005, 2006-2007, 2007-2008

FIRST Robotics

Sun Devil Rover Team, 2006-2007, 2007-2008

## SERVICE

### **PROFESSIONAL AND SCIENTIFIC SERVICE**

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#### **SCIENTIFIC AND PROFESSIONAL SOCIETY MEMBERSHIPS**

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ASME 1997-present

IEEE 1999-present

ASME Fellow 2015

IEEE Senior Member 2016

### **PROFESSIONAL SERVICE**

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**2017-2025 ASTM Standards Committee on Exoskeletons and Exosuits – Committee Officer**

**2018-2024 IEEE Technical Committee on Wearable Robotics**

**2014 IDETC Technical Program Chair (Premier Design Conference) (approx 1000 presentations, 1591 registrations)**

**2013 IDETC Mechanisms and Robotics Conference Chair**

**ASME Mechanism and Robotics Committee, 2004 – 2010**

Organization of the International ASME Mechanism and Robotics Conference

### **EDITOR ACTIVITIES**

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Associate Editor: Wearable Technologies, Open Access Journal, Cambridge University Press, Cambridge/wtc

Guest Editor for the International Robotics and Automation Magazine

Special Topic: Adjustable Passive Compliance

### **CONFERENCE ACTIVITIES**

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Program Committee: DETC 2009 Design Engineering Technical Conferences and Computers in Engineering Conference. **Chair of Novel Robots and Mechanisms** at the ASME DETC 2009 conference responsible for organizing and reviewing 36 conference papers.

Executive Committee: Biorob 2008

Program Committee: ICRA 2008

Program Committee: DETC 2007 Design Engineering Technical Conferences and Computers in Engineering Conference. **Chair of the Robotic Theory Symposium** at the ASME DETC 2007 conference responsible for organizing and reviewing 30 conference papers.

Program Committee: IROS 2006

Program Committee: Haptics 2006

Program Committee: DETC 2006 Design Engineering Technical Conferences and Computers in Engineering Conference. **Chair of the Robotic Theory Symposium** at the ASME DETC 2006 conference responsible for organizing and reviewing 16 conference papers.

Program Committee: IROS 2005

Review Committee: ICORR 2005

Program Committee: DETC 2005 Design Engineering Technical Conferences and Computers in Engineering Conference. **Co-chair of the Robotic Theory Symposium** at the ASME DETC 2005 conference responsible for organizing and reviewing 31 conference papers.

Evaluator for 2005 ASME Student Mechanism Competition

Session Organizer for Rehabilitation Robotics at the IEEE Conference on Medicine and Biology, 2004.

Program Committee: DETC2004 Design Engineering Technical Conferences and Computers in Engineering Conference. **Co-chair of the Robotic Systems Symposium** at the ASME DETC 2004 conference responsible for organizing and reviewing 28 conference papers.

Demonstration and Exhibit on Compliant Actuators at the IROS 2003 Conference in Las Vegas

Invited to the National Science Foundation Robotics and Computer Vision PI Workshop, 2003

Program Committee: DETC2002 Design Engineering Technical Conferences and Computers in Engineering Conference. **Co-chair of the Robotic Systems Symposium** at the ASME DETC 2002 conference responsible for organizing and reviewing 40 conference papers.

Program Committee: VI 2001 Vision Interface Annual Conference, 2001.

Session Chairman, Vision Based Control, 2002 IEEE International Conference on Robotics and Automation

Session Chairman, VI2001.

Session Chairman, Vision Based Control, 2001 IEEE International Conference on Robotics and Automation

Session Chairman, Novel Actuators, 7<sup>th</sup> Mechatronics Forum, 2000.

Evaluator for 2000 ASME Student Mechanism Competition

## **JOURNAL REFEREE**

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IEEE Transactions on Systems, Man and Cybernetics

ASME Journal of Mechanical Design

International Journal of Robotics and Automation

IEEE Transactions on Robotics and Automation

ASME JICSE Journal

Journal of Applied Bionics and Biomechanics

Psychonomic Bulletin and Review

Science

MacArthur Fellowship reviewer

## **PROPOSAL REVIEW**

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Invited to sit on the NSF Robotics Panel in May 2005

Invited to sit on the NSF Medical Assistance Panel in September 2007

NIH NICHD Review Panel, 2008, 2009, 2010, 2011, 2012, 2014

VA Rehabilitation Robotics Review Panel 2009, 2010, 2011

Review Robotics grants for the European Union, VIACTORS grant 2010, 2011, 2012

## **UNIVERSITY SERVICE**

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Associate Dean, Barrett, The Honors College, Polytechnic Campus, 2019-**present**

Sundevil Athletic Board, 2019-**present**

The Polytechnic School – Graduate Program Chair for Systems Engineering, 2018-2022

The Polytechnic School – Graduate Program Chair for MS Engineering, 2018-2022

School of Manufacturing Systems and Networks – Graduate Program Chair for Systems Engineering, 2022-**present**

School of Manufacturing Systems and Networks – Graduate Program Chair for Manufacturing Engineering, 2022-**present**

School of Manufacturing Systems and Networks – Department Faculty Review Committee, 2022-**present**

Ira. A. Fulton Schools of Engineering, DFAC Committee 2014-2016, 2016-2019

ASU Intellectual Property and Institutional Review Committee, 2010-**present**

Team Leadership Academy for Robotics Works, 2017-2018

ASU Academic Senate at the Polytechnic Campus, 2008-2009

ASU Polytechnic Dean Executive Council Committee 2010-2012

ASU Polytechnic College PTR Committee 2013-2014

SEMTE Mechanical Design Search 2014

SEMTE Robotics Search 2014

2010-2014 Honors Faculty Advisor for Engineering

## **DEPARTMENTAL SERVICE**

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Search Committees 2021-2022, Dean for Barrett, The Honors College, Manufacturing Systems and Networks Director, Barrett Honors Faculty Fellow, Barrett Recruiter, Robotics Lecturer, Cyber-manufacturing, Cybersecurity for manufacturing

## **2018 Development of the MS Degree in Robotics**

2018 Committee member of the Southwest Robotics conference

2017 TRIAG meeting for The Polytechnic School

2013-2014 Department Hiring Committee – Robotics, Manufacturing

2011-2012 Engineering Integration Task Force

2010-2012 ASU Polytechnic Honor's College Committee

2010-2011 Department Hiring Committee

Development of the new curriculum for the Department of Engineering at the Polytechnic Campus

Engineering 2.0 Committee

### **Development of a new robotics curriculum for the Department of Engineering at the Polytechnic Campus, 2010**

Promotion and Tenure Committee, Department of Engineering, 2009-2011-2012

MAE Publicity Committee

MAE Design Curriculum Committee

MAE Curriculum Review on Saturday, May 7, 2000, and May 2001

Search Committee – Manufacturing Position, Spring 2004

CEAS Award for Recognition of Contribution and Support to CEAS Student Affairs, December 2002.

## **STUDENT SERVICE**

Started a Raytheon Design Team on the Polytechnic campus.

Advising Team for MAE department, responsible for about 80 students per year

Presentation at Engineering and Applied Sciences Day, October 22, 1999

Career Day at Brophy High School

**Mentoring FIRST Robotics** at three local high schools, Brophy, Xavier, and North High School, devoted 100 hours per year for January 2000, 2001, 2002, 2003, and 2004

## **PUBLICATIONS IN POPULAR PRESS**

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Wearable Rehab Robots, WDEF-TV News 12, Apr 14, 2005 8:03 AM EDT

CBS 2 Chicago WBBM-TV, Robots Help Rehabilitate Stroke Patients, May 12, 2005 3:41 pm US/Central

CBS 2 New York, Robots Help Rehabilitate Stroke Patients, May 24<sup>th</sup>, 2005

NBC, Stroke Rehabilitation, May 25<sup>th</sup>, 2005

ABC 15, Phoenix, Relying on Robots, June 13<sup>th</sup>, 2005

CBS-5 Health Watch, Green Bay, June 23<sup>rd</sup>, 2005 9:29 am

ABC News, Omaha, Robotic Device Assists Stroke Patients: This rehab may improve quality of life, May 2005

**ABC World News Tonight, Medicine on the Cutting Edge, May 17th, 2005**, Robot Guides Stroke Patients' Recovery: Electronic Arm Helps Patients Practice Movements, by NED POTTER

Sports Saturday, June 10<sup>th</sup>, 2006, **New York Times**, Nuts-and-Bolts Ballplayer for a Space Age Infield, by Lee Jenkins

The Issue: Robots Taking Over? Playing 2<sup>nd</sup> base: R2-D2, Editorial, June 19<sup>th</sup>, 2006 The Arizona Republic

**"The Role of Robots"**, ASU Research Review, KAET Channel 8, October 28 and November 2, 2003.

The 6th Annual Year in Ideas: The Robot Fielder, December 10th, 2006, by Arianne Cohen, **New York Times Magazine**

Next generation of powered prosthetic devices based on lightweight energy storing springs. What's next network - Science and Technology - May 2, 2007

"Sparky;" the Ankle Prosthetic of the Future, Med Gadget - May 2, 2007

Researchers create next generation prosthetic devices - News-Medical.net - May 2, 2007

ASU researchers putting new spring into amputees' step, MSN Money, May 1, 2007

Smart Prosthesis of the future created, United Press International - May 3, 2007

Smart Prosthesis of the future created, Podiatry News, Foot News - May 3, 2007

The World's First Powered Ankle, Technology Review - By Emily Singer and Duncan Graham-Rowe - May 11, 2007

SPARKy the prosthetic ankle set to "revolutionize prosthetics", Posted May 3rd 2007 by Paul Miller

ASU, Walter Reed researchers create prosthesis of the future, ASU Insight -May 11, 2007

Innovations Report -By Chris Lambrakis - May 03, 2007

EurekAlert - May 1, 2007

Brightsurf Science News - May 2, 2007

FusePress - May 2, 2007

Medical News Today - May 3, 2007

newsrx.com - May 1, 2007

ScienceDaily - May 2, 2007

VA News Flash - VA Watchdog dot Org By Larry Scott at -May 03, 2007

First Science News - May 1, 2007

Discovery News - By Tracy Staedter - May 31, 2007

Arizona researchers putting new spring into amputees' step, The Business Journal of Phoenix - May 1, 2007

Washington Business Journal -by Ty Young May 3, 2007, Researchers take step forward in design of new prosthesis

Creating a Future Prosthesis for Today's Military Amputees, Orthotics and Prosthetics, September 1, 2007

Researchers design new prosthesis, ASU, August 6, 2007

Creating a Future Prosthesis for Today's Military Amputees, Orthotics and Prosthetics, September 1, 2007

Can the robot come out to play?, ASU, April 3, 2008

How to build a better ballplayer, ASU, July 10, 2008

**Discovery Channel, 2008, “Toad research could leapfrog to new muscle model”, show was called “Toady Tendons”, December 3, 2008, 8 minutes**

Robotic ankle only steps away from daily use, AZ Republic, December 21, 2009

Device reflects value of research for ASU, AZ Republic, December 21, 2009

SPARKy device helps amputees return to normal lives, ASU, December 2009

Mesa Talking with Scott Anderson, December 2009

### **National Geographic Magazine, Issue on The Bionic AGE, January 2010**

Innovative prosthetic ankle to mobilize amputees, AZ State Press, January 22, 2010

Researchers develop new robotic prosthetic technology to aid amputees, College Times, January 21, 2010

Exciting Benefits of Powered Prosthetic Systems, Lt. Col. Joseph K. Hitt, PhD; Kevin Hollander, PhD; and Thomas Sugar, PhD, The O&P EDGE, October 2010

### **Dean of Invention: Introducing the Age of Bionic Limbs, October 19, 2010**

Sports Illustrated, August 8, 2011, "New and Improved" by Alexander Wolff

AFSOR Climbing Assist Device, 2011-2012, Spiderman Project, **Best Buy Commercial, Co-advisor with Dr. Sangram Redkar**

**ASU VIMEO video on the Jet Pack approximately 3 million views for ASU**

**CBS Good Morning News:**

<http://www.cbsnews.com/news/militarys-darpa-lab-creates-wearable-robot-to-help-soldiers-run-faster/>

**Sports Illustrated:**

<http://www.si.com/edge/2014/11/20/scientist-builds-real-life-jetpack-for-runners>

[\*\*https://aabme.asme.org/posts/a-more-natural-approach-to-passive-ankle-prostheses\*\*](https://aabme.asme.org/posts/a-more-natural-approach-to-passive-ankle-prostheses)

**APEx Exoskelton**

<https://www.travis.af.mil/News/Article/2620533/travis-partnership-springs-air-force-forward-with-new-aerial-porter-exoskeleton/>

<https://www.airforce-technology.com/news/aflcmc-and-amc-partner-with-asu-on-aerial-port-exoskeleton-development/>

<https://news.asu.edu/20210712-solutions-air-force-exoskeleton-heavy-lift-asu>