**STEVEN DUBOWSKY**
Professor of Mechanical Engineering and of Aeronautics and Astronautics
Massachusetts Institute of Technology
Cambridge, MA 02139
(617) 253-2144
e-mail: dubowsky@mit.edu

## EDUCATION

| | | |
|---|---|---|
| 1963 | BME | Rensselaer Polytechnic Institute, Troy, New York<br>Mechanical Engineering and Control Systems |
| 1964 | MS | Columbia University<br>School of Engineering and Applied Science<br>New York City, New York |
| 1971 | ScD | Columbia University<br>School of Engineering and Applied Science<br>New York City, New York |

Registered Professional Engineer, State of California (Control Systems)

## ACADEMIC ACTIVITIES

Dr. Dubowsky is a Professor Emeritus in the Mechanical Engineering the Department of Mechanical Engineering and in the Department of the Aeronautics and Astronautics at MIT, Cambridge. He is currently also a PhD Advising Professor in the Department of Mechanical and Industrial Engineering at Northeastern University. His research activities have been principally in the dynamic behavior of nonlinear machines and electromechanical systems. His work includes analytical and experimental work based on parameter identification methods to locate the sources of noises and performance-limiting factors in machines. He has studied the effects of system elasticity on the dynamics and control-ability mechanisms using advanced structural dynamics techniques. More recently, his work has been focused on the planning, control and design of robotic and mechatronic systems. This work includes the development of intelligent systems for the elderly, medical devices, space robots, rough terrain systems for such application exploration. Dr. Dubowsky and his students have developed algorithms for self-learning adaptive control of rigid and flexible robotic manipulators, and for the optimal control and planning of robotic systems. More recently Professor Dubowsky has been working on the design of PV solar systems with a focus on field systems, including for developing nations.

In his tenure at MIT Professor Dubowsky has been the Director of the MIT Mechanical Engineering Field and Space Robotics Laboratory. He has been the Associate Director of the Interdepartmental Laboratory for Manufacturing and Productivity and for six years he was the Head of the Systems and Design Division of the Mechanical Engineering Department. During the 1977-1978 academic year, he was a visiting faculty member in the Engineering Department, Cambridge University, Cambridge, England, and a Visiting Fellow at Queen's College, Cambridge. During the 1988-89 academic year, Professor Dubowsky was a visiting professor at the California Institute of Technology and in the summers of 1991 to 1994 a visiting professor at the Université Pierre et Marie Curié in Paris, France. In the summer of 1992 he taught at the School for Advanced Studies in Industrial and Applied Mathematics (SASIAM) in Bari, Italy. In Fall of 1995 he held the positions of Visiting Professor and Distinguished NATO Fellow at the Laboratoire de Robotique de Paris, Paris France. In the winter of 1996 he was Visiting Professor at the Naval Postgraduate School, Monterey, California. During the 2002/2004 academic years he was a Visiting Professor at Stanford University.

His research has been sponsored by a number of industrial firms in the United States, Europe and Asia, as well as NSF, NASA, DARPA, DOE, The US Army, The French agencies EDF and CNRS, the Korean KEPRI, the British SERC, Japan's NASA, and others. He is a Fellow the ASME and IEEE. Dr. Dubowsky is currently the Chief Technology Officer of PVpure Inc. of Cambridge, MA.

## HONORS AND SPECIAL RECOGNITION RECEIVED

| | |
|---|---|
| Best Paper Award 11th ASME Mechanisms Conference | 10/71 |
| Selected as One of the Outstanding Young Men of America for 1977 | 3/77 |

United States Junior Chamber of Commerce U.S. Jaycees

| | |
|---|---|
| Elected 10-Year Term as an Associate of the Danforth Foundation | 4/77 |
| Elected Visiting Fellow, Queens' College Cambridge University | 9/77-9/78 |
| Elected Chairman of the ASME Design Engineering Technology Conference | 9/78-7/80 |
| Best Paper Award at the 1978 ASME Design Engineering Technical Conference | 9/78 |
| American Men and Women of Science | 79-Present |
| Who's Who in the West | 79-Present |
| Best Paper Award for 1979, Dynamic Systems and Control | 12/79 |
| Division of the ASME | |
| Who's Who in Education | 80-Present |
| Who's Who in Technology Today | 80-Present |
| Member Honorary Editorial Board, Mechanisms and Machine | 80-Present |
| Theory *J. of Int. Fed. of the Theory of Machines and Mechanisms* | |
| Elected General Chairman, 1980 ASME Design Engineering | 10/80 |
| Technical Conferences, Beverly Hills, CA | |
| Best Paper Award 1982 ASME Design Technical Conference | 9/82 |
| Who's Who in America | 85-Present |
| Elected Fellow, American Society of Mechanical Engineers | 88 |
| Elected Honorary Senior Research Fellow | 5/93-6/93 |
| UK Scientific and Engineering Research Council SERC | |
| Elected to Distinguished Lecturers Program | 1993-1995 |
| IEEE Robotics and Automation Society | |
| Elected as a Distinguished NATO Fellow | 9/95 -1/96 |
| Paris, France | |
| Elected as a Distinguished CNRS Fellow | 9/95 -1/96 |
| Paris, France | |
| Finalist, Best Paper Award, 1996 IEEE International Conference | 4/96 |
| on Robotics and Automation, Minneapolis, MN. | |
| Best Paper Award for Manipulation, 1998 IEEE International Conference | 4/96 |
| on Robotics and Automation, San Francisco , CA. | |
| Elected Fellow of the Institute of Electrical and Electronic Engineers | 1/01 |
| ASME Machine Design Award | 2001 |
| Best Paper Award ASME 27th Biennial Mechanisms and Robotics Conference | 9/02 |
| Selected as a Fellow of the NASA Institute of Advanced Concepts | 9/02 – 8/07 |
| Best Paper Award–World Congress of the International Federation for the | 6/07 |
| Promotion of Mechanism and Machine Science, Besancon, France | |
| Best Paper Award, 10 International Conferences on Climbing and Walking Robots, | 7/2007. |
| Singapore | |
| Best Paper Award, ASME 2010 Mechanisms and Robotics Conference, Montreal, | 8/2010 |

Canada.

Best Paper Award, ASME 2011, Mechanisms and Robotics Conference, Washington DC,   8/2011

The ASME Achievement Award for Robotics and Mechanisms            8/2013

**PROFESSIONAL ACTIVITIES**

American Society of Mechanical Engineers (Fellow)

Institute of Electrical and Electronic Engineering (Fellow)

ASME Mechanisms Committee (6-year elected term), Elected Chairman, 1978-80

Associate Editor, *Mechanism and Machine Theory*, 1975-81

U.S. Council for the Theory of Machines and Mechanisms

Member, General Committee, ASME Design Engineering Division, 1979-Present

Senior Member, Robotics Institute of the Society of Manufacturing Engineers, 1983-Present

Member, Executive Committee, ASME Design Engineering Division, 1983-Present

Founding Editor, *Journal of Mechanisms, Transmissions and Automation in Design*, 1982-87

In addition to his university duties, Professor Dubowsky has consulted for a number of firms in the area of design and analysis of electromechanical systems as well as consulting to legal firms in the area of product safety and patents. These consulting assignments have dealt with such widely spread devices as vibration isolation systems, large scale telescopes tracking systems, construction equipment, the design of high speed automated manufacturing machinery, and robotic manipulators, and have included the following organizations:

Hughes Aircraft Corporation, El Segundo, CA

Lockheed Research Laboratories, Palo Alto, CA

Optical Science Consultants (Associate), Yorba Linda, CA

Perkin-Elmer Corporation (Corporate Consultant), Wilton, CT

Wyle Laboratories, Los Angeles, CA

SRI International, Menlo Park, CA

EG & G Inc., Wellesley, MA

Schlumberger Corporation, Corporate Research Laboratories, Ridgefield, CT

Foster-Miller Corp., Waltham, MA

SVG Corporation, Mountain View, CA

Texas Instruments, Dallas, TX

General Dynamic, Phoenix, AZ

Lincoln, Lavatories, Concord, MA

FSRobotics, Boston, MA

Northrop Grumman Corporation, Los Angeles, CA

Siemens Corporation, Munich Germany.

Robert E. Bosch Company, Germany

QinetiQ of North America, Washington, DC.

Prior to becoming a faculty member, from 1964 to 1971, Professor Dubowsky was a Senior Engineer with the Perkin-Elmer Corporation, Optical Technology Division, in Danbury, Connecticut, and was involved in the design and analysis of complex mechanisms, electromechanical and electro-optical systems used in precision, high-speed optical systems and devices. These designs require the solutions to problems in the areas of applied mechanics and servomechanisms using both classical and analytical methods and complex numerical techniques. Duties also involved the direction of experimental programs for the development of electronics and electromechanical hardware for use in these systems.

Other major assignments included: the development of numerical processing of photographic scenes to improve signal to noise levels and image enhancement; the analysis of thermal effects on optical system performance; the study of spacecraft dynamics and attitude control systems as to interactions with

scientific instrumentation performance; the development of mathematical models for on-line computer evaluation of system elements during manufacture.  Earlier industrial positions have been with the General Dynamics Corporation, Electric Boat Division and the American Electric Power Service Corporation.

Professor Dubowsky has authored and co-authored over three hundred professional and scholarly technical papers.  Below are representative papers written in the past 10 years.

**PRINCIPAL PUBLICATIONS IN THE LAST 10 YEARS.**

Sujan, V. and Dubowsky, S. "Design of a Lightweight Hyper-redundant Deployable Binary Manipulator," ASME Journal of Mechanical Design, Volume 126, No. 1, January 2004, pp 29-39.

Iagnemma, K, Brooks, C.A., and Dubowsky, S., " Visual, Tactile, and Vibration-Based Terrain Analysis for Planetary Rovers," Proceedings of the 2004 IEEE Aerospace Conference, Big Sky Montana, March 6-13 2004.

Iagnemma, K., Spenko, M., Golda, D., and Dubowsky, S., Reactive Navigation of High-Speed Mobile Robots in Rough Terrain, Proceeding of the SPIE Conference on Unmanned Ground Vehicle Technology, Orlando, FL, March 2004.

Bolzmacher, C., Hafez, M., Khoudja, B., Bernardoni, P., and Dubowsky, S., "Polymer Based Actuators for Virtual Reality Devices," SPIE Smart Structures Conference, San Diego, CA, March 14-18, 2004

Lichter, M. D.  and Dubowsky, S.  "State, Shape, and Parameter Estimation of Space Objects from Range Images," Proceedings of the IEEE Int. Conference on Robotics and Automation (ICRA '04), New Orleans, April 2004.

Vogan, J., Kacher, D., Wingert,A. , Hafez, H., Plante,J.S,  Jolesz, F., and Dubowsky, S., "Manipulation in MRI Devices using Electrostrictive Polymer Actuators: With an Application to Reconfigurable Imaging Coils," Proceedings of the IEEE Int. Conference on Robotics and Automation (ICRA '04), New Orleans, April 2004.

Golda D., Iagnemma, K., and Dubowsky,S., "Probabilistic Modeling and Analysis of High-Speed Rough-Terrain Mobile Robots," Proceedings of the IEEE Int. Conference on Robotics and Automation (ICRA '04), New Orleans, April 2004.

Sujan, V.A., Dubowsky, S, Huntsberger, H., Aghazarian, H., Cheng, Y. and Schenker, P., "An Architecture for Distributed Environment Sensing with Application to Robotic Cliff Exploration," The Journal of Autonomous Robots, Volume 16, No. 3, May 2004, pp 287-311.

DF Kacher, J Vogan, A Wingert, M Hafez, J-S Plante, S Dubowsky, FA Jolesz. "Development of a Reconfigurable MRI Coil using Electrostrictive Polymer Artificial Muscle Actuators," Proceedings of the International Society of Magnetic Resonance in Medicine (2004) p3394, 12th Scientific Meeting, (May 15-21, 2004) Kyoto, Japan.

Ueno, H., Vickram, M, Steven Dubowsky,S., Sekiguchi, T., Mitsushige Oda, M., and Ohkami, Y, "Simulation Analysis and Experiments of On-orbit Assembly Behavior on Flexible Structure by Cooperative Robots," 24th International Symposium on Space Technology, Miyazaki, Japan, May 30 – June  6, 2004.

Sujan, V.A. and Dubowsky, S. "Visually Guided Cooperative Robot Actions Based on Information Quality," Journal of Autonomous Robots, Vol 17, August 2004, pp. 1-22.

Yu,H., Spenko, H. and Dubowsky, S., "Omni-directional Mobility Using Active Split Offset Castors," ASME Journal of Mechanical Design, Volume 126, No.5, pp 822-829, September 2004.

Iagnemma, K., Kang, S., Shibly, H. and Dubowsky, S. "On-Line Terrain Parameter Estimation for Wheeled Mobile Robots with Application to Planetary Rovers," IEEE Transactions on Robotics and Automation, Volume 20, No. 5, October 2004, pp 921-927.

Iagnemma, K and Dubowsky, S., "Traction Control of Wheeled Robotic Vehicles in Rough Terrain," The International Journal of Robotics Research, Volume 23, No. 10-11, October-November 2004, pp 1029-1040.

Iagnemma, K. and Dubowsky, S. "Estimation, Planning, and Control of Mobile Robots in Rough Terrain with application to Planetary Rovers," Springer Tracts in Advanced Robotics series (STAR), Heidelberg, 2004.

Shibly, H., Iagnemma, K, and Dubowsky, S., "An Equivalent Soil Mechanics Formulation for Rigid Wheels in Deformable Terrain, with Application to Planetary Exploration Rovers'" The Journal of Terra-mechanics, Volume 42, pp 1-13, 2005.

Dubowsky, S., Boston, P., Iagnemma, K., Lambeth, D., Liberatore, S., and Plante, J.S., "Microbots for Large-Scale Planetary Surface and Subsurface Exploration," Proceedings of the Space Technology and Applications International Forum, Albuquerque, NM, February 13-17, 2005

Marco A. Meggiolaro, Steven Dubowsky and Constantinos Mavroidis, "Geometric and elastic error calibration of a high accuracy patient positioning system", Mechanism and Machine Theory, Volume 40, Issue 4, pp.415-427, April 2005.

Sujan,V. A., and Dubowsky, S., An Efficient Information-Based Visual Robotic Mapping in Unstructured Environment, The International Journal of Robotics Research. Vol. 24, No. 4, April 2005.

Hiroshi Ueno (NASDA), Steven Dubowsky, Chris Lee, Chi Zhu(MIT), Yoshiaki Ohkami, Shuichi Matsumoto, Mitsushige Oda(NASDA) "Space Robotic Mission Concepts For Capturing Stray Objects," The Journal of Space Technology, Transactions of the JSASS, (In Press).

Brooks, C., Iagnemma, K., and Dubowsky S., "Vibration-based Terrain Analysis for Mobile Robots, Proceedings of the IEEE Int. Conference on Robotics and Automation (ICRA '05), Barcelona, Spain, April 2005.

Matthew D. Lichter, M.D., and Dubowsky, S., "Shape, Motion, and Parameter Estimation of Large Flexible Space Structures using Multiple Range Images," Proceedings of the IEEE Int. Conference on Robotics and Automation (ICRA '05), Barcelona, Spain, April 2005.

Brooks, C,A., Iagnemma, K.D. and Dubowsky, S., Dubowsky, Visual Wheel Sinkage Measurement for Planetary Rover Mobility Characterization, Autonomous Robots, Vol. 21, Number 1, August, 2006, pp. 55-64.

Lichter, M.D., Dubowsky,S., Ueno, H., and Mitani, S., "Shape, Motion, and Parameter Estimation of Flexible Space Structures using Laser Rangefinders," Robotics: Science and Systems 2005, Cambridge, MA, June 8-11, 2005.

Plante, J. S, Santer, M., Pellegrino, S., and Dubowsky, S. "Compliant Bistable Dielectric Elastomer Actuators For Binary Mechatronic Systems, Proceedings of the ASME Conference on Mechanisms and Robotics, Long Beach California, September, 23-29, 2005.

Tzeranis, D., Ishijima, Y., and Dubowsky, S., "Manipulation of Large Flexible Structural Modules by Robots Mounted on Large Flexible Structures," Proceedings of the Eighth International Symposium on Artificial Intelligence, Robotics and Automation in Space, I-SAIRAS, Munich, Germany, September, 2005.

Ishijima, Y., Tzeranis, D., and Dubowsky, S., "On-Orbit Maneuvering of Large Space Flexible Structures by Free-Flying Robots," Proceedings of the Eighth International Symposium on Artificial Intelligence, Robotics and Automation in Space, I-SAIRAS, Munich, Germany, September, 2005.

Dubowsky, S., Quinn, R., Marzwell, N. and Bradley, A.T., "Joint Technical Architecture for Robotic Systems (JTARS)," Proceedings of the Eighth International Symposium on Artificial Intelligence, Robotics and Automation in Space, I-SAIRAS, Munich, Germany, September, 2005.

Mitani, S., Lichter, MD., Dubowsky, S., and Ueno, H., "Ground Experiment about Shape, Motion, and Parameter Estimation of Flexible Space Structures using Laser Rangefinder", Proceedings of the Mechanical Engineering Congress, 2005, Tokyo, Japan, September 19-22 2005 (in Japanese).

Boston, P.J. and Dubowsky, S., "Hopping Microbot Access to Subsurface (Cave) and Rugged Terrain on Mars and Hazardous Extreme Earth Astrobiology Sites, Proceedings of the American Geophysics Union Congress, San Francisco, CA, 5–9 December 2005.

Plante, JS., Dubowsky, S., "On the Nature of Dielectric Elastomer Actuators and Its Implications for Their Design," Proceedings of the SPIE Smart Structures and Materials 2006: Electroactive Polymer Actuators and Devices, Proceedings of SPIE, San Diego, CA, March 2006.

# DOCKET ALARM

# Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

## Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

## Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

## Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

## API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

**LAW FIRMS**
Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

**FINANCIAL INSTITUTIONS**
Litigation and bankruptcy checks for companies and debtors.

**E-DISCOVERY AND LEGAL VENDORS**
Sync your system to PACER to automate legal marketing.