

EXHIBIT 39

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Employment

- 1997-present **Gordon McKay Professor of Engineering**, School of Engineering and Applied Sciences, Harvard University. Conducting research in human-machine interfaces, biomechanics, tactile sensing, and human and robotic manipulation; teaching graduate and undergraduate engineering courses.
- 1994-1997 **Associate Professor of Mechanical Engineering**, Harvard University.
- 1990-1994 **Assistant Professor of Mechanical Engineering**, Harvard University.
- 1984-1990 **Research Assistant**, Mechanical Engineering Department, Stanford University.
- 1981-1983 **Research Physicist**, High Temperature Gasdynamics Laboratory, Stanford University. Developed new optical and electronic research instruments, conducted flow visualization and combustion diagnostics experiments.
- 1979-1981 **Electronics Engineer**, Kratos Display Systems, Los Gatos, CA. Designed analog and digital electronics.

Secondary Academic Appointments

- Member of the Faculty, Harvard-MIT Division of Health Sciences and Technology, 1999-present.
- Visiting Professor, INRIA, Sophia-Antipolis, France, Spring 2004.
- Visiting Scientist, Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Fall 1998.
- Visiting Scholar, Mechanical Engineering Department, Stanford University, Spring 1999.

Education

- 1985-1990 Doctor of Philosophy in Mechanical Engineering, Stanford University.
- 1983-1985 Master of Science in Mechanical Engineering, Stanford University.
- 1975-1979 Bachelor of Arts in Physics, Reed College, Portland, Oregon.

Selected Professional Awards and Honors

- Fellow, American Institute for Medical and Biological Engineering, 2007.
- Keynote address, EuroHaptics Conference, Munich, June 2004.
- Best poster award, Sixth International Meeting of the Society for Minimally Invasive Therapy, Berlin, 1994 (with William Peine).
- Whitaker Foundation Biomedical Engineering Research Grant (Career development award), 1995.
- National Science Foundation Young Investigator Award, 1993.
- Best paper award, American Institute of Aeronautics and Astronautics Conference, Seattle, 1983 (with George Kychakoff and Ronald Hanson).

Selected Professional Service

Journals

Editorial Board, *Haptics-e*, 1998-present.

Associate editor, *IEEE Transactions on Robotics and Automation*, 1994-1998.

Conferences

Area Chair, Robotics: Science and Systems Conference, Philadelphia, August 16th-19th, 2006; program committee member 2007.

Co-Chair, International Program Committee, World Haptics Conference (First Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems), Pisa, Italy, 18-20 March, 2005.

Program Committee, International Symposium on Medical Robotics and Computer Assisted Surgery/MICCAI, 1994, 1995, 1997, 1998, 2000, 2002-2007.

Chair and Organizer, Annual Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, Atlanta, Nov. 1996; Dallas, Nov. 1997; and Anaheim, 1998 (with Susan J. Lederman); program committee member, 1999-2007.

Program Committee, IEEE International Conference on Robotics and Automation, 1994, 1997, 1998, 2005.

Program committee, IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2004.

Program Committee, Second International Symposium on Medical Simulation, 2004.

Program Committee, International Symposium on Surgery Simulation and Soft Tissue Modeling (IS4TM 2003), Juan-Les-Pins, France, June 2003.

Program Committee, IEEE International Conference on Systems, Man, and Cybernetics, Tokyo, 1999.

Program Committee, Frontiers of Engineering Symposium, National Academy of Engineering, Irvine, CA, Nov. 1998.

Funding panels

Study section, National Institutes of Health, 2003, 2005.

Funding Review Panel Member, National Science Foundation, 1994, 2000.

Visiting Committee

Department of Mechanical and Process Engineering (Maschinenbau und Verfahrenstechnik), Eidgenössische Technische Hochschule (ETH) Zürich, 2006-2007.

PUBLICATIONS

Journal Articles

46. Vasilyev NV, Novotny PM, Martinez JF, Loyola H, Salgo IS, Howe RD, del Nido PJ. Stereoscopic Vision Display Technology in Real-Time Three-Dimensional Echocardiography-Guided Intracardiac Beating-Heart Surgery. *Journal of Thoracic and Cardiovascular Surgery*, in press, 2007.
45. Novotny PM, Stoll JA, Vasilyev NV, Del Nido PJ, Dupont PE, Howe RD, "GPU Based Real-time Instrument Tracking with Three Dimensional Ultrasound," *Medical Image Analysis*, in press, 2007.
44. Linguraru MG, Kabla A, Marx GR, del Nido PJ, Howe RD, "Real-Time Tracking and Shape Segmentation of Atrial Septal Defects in 3D Echocardiography," *Academic Radiology*, in press, 2007.
43. Wagner CR, Howe RD, "Force Feedback Benefit Depends on Experience in Multi Degree of Freedom Robotic Surgery Task," *IEEE Transactions on Robotics*, in press, 2007.
42. Linguraru MG, Vasilyev NV, Marx GM, Tworetzky W, del Nido PJ, Howe RD, "Fast Block Flow Tracking of Atrial Septal Defects in 4D Echocardiography," *Medical Image Analysis*, in press, 2007.
41. Diamond SG, Davis OC, Howe RD, "Heart rate variability as a quantitative measure of trance depth," *International Journal of Clinical and Experimental Hypnosis*, in press, 2007.
40. Linguraru MG, Vasilyev NV, del Nido PJ, Howe RD, "Statistical Segmentation of Surgical Instruments in 3D Ultrasound Images," *Ultrasound in Medicine and Biology* **33**(8): 1428-37, 2007.
39. Wagner CR, Stylopoulos N, Jackson PG, Howe RD, "The Benefit of Force Feedback in Surgery: Examination of Blunt Dissection," *Presence*, **16**(3): 252-262, June 2007.
38. Novotny PM, Jacobsen SK, Vasilyev NV, Kettler DT, Salgo IS, Dupont PE, del Nido PJ, and Howe RD, "3D ultrasound in robotic surgery: performance evaluation with stereo displays," *International Journal of Medical Robotics and Computer Assisted Surgery*, **2**(3):279-285, 2006.
37. Diamond SG, Davis OC, Schaechter JD, Howe RD, "Hypnosis for Rehabilitation after Stroke: Six Case Studies," *Contemporary Hypnosis* **23**(4), 173-180, 2006.
36. Kerdok AE, Ottensmeyer MP and Howe RD, "The effects of perfusion on the viscoelastic characteristics of liver," *Journal of Biomechanics* **39**(12):2221-31, 2006.
35. Dollar AM and Howe RD, "A Robust Compliant Grasper via Shape Deposition Manufacturing," *IEEE/ASME Transactions on Mechatronics* **11**(2):154-161, April 2006.
34. Suematsu Y, Martinez JF, Wolf BK, Marx GR, Stoll JA, DuPont PE, Howe RD, Friedman JK, del Nido PJ. "Three-dimensional echo-guided beating heart surgery without cardiopulmonary bypass: atrial septal defect closure in a swine model," *Journal of Thoracic and Cardiovascular Surgery* **130**(5):1348-57, November 2005.
33. Gunter HE, Howe RD, Zeitels SM, Kobler JB, Hillman RE, "Measurement of vocal fold collision forces during phonation: Methods and preliminary data" *Journal of Speech, Language, and Hearing Research* **48**(3):567-76, June 2005.

32. Dollar AM, Howe RD, "Towards grasping in unstructured environments: Grasper Compliance and Configuration optimization," *Advanced Robotics*, **19**(5):523-543, June 2005.
31. T.J. Debus P.E. Dupont, and R.D. Howe," Distinguishability and Identifiability Testing of Contact State Models," *Advanced Robotics*, **19**(5):545-566, June 2005.
30. Samosky J, Burstein D, Grimson WE, Howe R, Martin S, Gray ML. Spatially-localized correlation of dGEMRIC-measured GAG distribution and mechanical stiffness in the human tibial plateau *Journal of Orthopedic Research* **23**(1):93-101, January 2005.
29. Suematsu Y, Marx GR, Stoll JA, DuPont PE, Cleveland RO, Howe RD, Triedman JK, Mihaljevic T, Mora BN, Savord BJ, Salgo IS, del Nido PJ, "Three-dimensional echocardiography-guided beating-heart surgery without cardiopulmonary bypass: a feasibility study," *Journal of Thoracic and Cardiovascular Surgery* **128**(4):579-87, October 2004.
28. T. Debus, T.-J. Jang, P. Dupont, and R. Howe, "Multi-Channel Vibrotactile Display for Teleoperated Assembly," *International Journal of Control, Automation & Systems* **2**(3):390-397, September 2004.
27. C.R. Wagner, S.J. Lederman, R.D. Howe, "Design and Performance of a Tactile Shape Display Using RC Servomotors," *Haptics-e* **3**(4), August 2004.
26. T.J. Debus, P.E. Dupont, and R. D. Howe, "Contact State Estimation using Multiple Model Estimation and Hidden Markov Models," *International Journal of Robotics Research* **23**(4-5):399-413, April-May 2004.
25. J.W. Cannon, J.A. Stoll, S.D. Selha, P.E. Dupont, R.D. Howe, and D.F. Torchiana, "Port Placement Planning in Robot-Assisted Coronary Artery Bypass," *IEEE Transactions on Robotics and Automation* **19**(5): 912-17, October 2003.
24. J. W. Cannon, J. A. Stoll, I. S. Salgo, H. B. Knowles, R. D. Howe, P. E. Dupont, G. R. Marx, and P. J. del Nido, "Real Time 3-Dimensional Ultrasound for Guiding Surgical Tasks," *Computer Aided Surgery* **8**(3):82-90, 2003.
23. Cannon JW, Howe RD, Dupont PE, Triedman JK, Marx GR, del Nido PJ. "Application of robotics in congenital cardiac surgery," *Seminars in Thoracic and Cardiovascular Surgery - Pediatric Cardiac Surgery Annual* **6**:72-83, 2003.
22. A.E. Kerdok, S.M. Cotin, M.P. Ottensmeyer, A.M. Galea, R.D. Howe, and S.L. Dawson, "Truth Cube: Establishing Physical Standards for Real-Time Soft Tissue Simulation," *Medical Image Analysis* **7**(3):283-91, September 2003.
21. Diamond S.G., Howe R.D., "Measuring Hypnosis: Relating the Subjective Experience to Systematic Physiological Changes," *InterJournal of Complex Systems*, 541, 2002.
20. Wellman, P.S, Dalton, E.P., Krag, D., Kern, K.A., Howe, R.D. "Tactile Imaging of Breast Masses: First Clinical Report," *Archives of Surgery* **136**(2):204-08 Feb. 2001.
19. Pawluk, D.T.V. and Howe, R. D. "Dynamic contact of the human fingerpad against a flat surface." *ASME Journal of Biomechanical Engineering* **121**(6):605-611, December 1999.
18. P. Dupont, T. Schulteis, P. Millman, and R. D. Howe, "Automatic Identification of Environment Haptic Properties," *Presence* **8**(4):392-409, August 1999.

17. Pawluk, D.T.V. and Howe, R. D. "Dynamic Lumped Element Response of the Human Fingerpad." *ASME Journal of Biomechanical Engineering* **121**(2):178- 184, April 1999.
16. R. D. Howe and Y. Matsuoka, "Robotics for surgery," *Annual Review of Biomedical Engineering*, **1**:211-240, 1999.
15. D. T. V. Pawluk, J. S. Son, P. S. Wellman, W. J. Peine, and R. D. Howe. "A Distributed Pressure Sensor for Biomechanical Measurements," *ASME Journal of Biomechanical Engineering* **102**(2):302-305, April 1998.
14. A.Z. Hajian and R.D. Howe, "Identification of the mechanical impedance at the human finger tip," *ASME Journal of Biomechanical Engineering*, **119**(1):109-114, Feb. 1997. Also presented at the International Mechanical Engineering Congress, American Society of Mechanical Engineers, Chicago, IL, November 1994, Proceedings ed. C. J. Radcliffe, DSC-vol. 55-1, p. 319-327.
13. R. D. Howe and M. R. Cutkosky, "Practical force-motion models for sliding manipulation," *International Journal of Robotics Research* **15**(6):557-572, December 1996.
12. J. S. Son, M. R. Cutkosky, and R. D. Howe, "Comparison of contact sensor localization abilities during manipulation," *Robotics and Autonomous Systems*, **17**(4):217-233, June 1996. Also presented at IROS '95: IEEE/RSJ International Conference on Intelligent Robots and Systems, Pittsburgh, PA, August 5-9, 1995, Proceedings vol. 2, p. 96-101.
11. D. A. Kontarinis and R. D. Howe, "Tactile display of vibratory information in teleoperation and virtual environments," *Presence*, **4**(4):387-402, 1995.
10. R. D. Howe, W. J. Peine, D. A. Kontarinis, and J. S. Son, "Remote palpation technology," *IEEE Engineering in Medicine and Biology*, **14**(3):318-323, May/June 1995.
9. R. D. Howe, "Tactile sensing and control of robotic manipulation," *Journal of Advanced Robotics*, **8**(3):245-261, 1994.
8. R. D. Howe and M. R. Cutkosky, "Dynamic tactile sensing: Perception of fine surface features with stress rate sensing," *IEEE Transactions on Robotics and Automation* **9**(2):140-151, April 1993.
7. B. Edin, R. D. Howe, G. Westling, and M. R. Cutkosky, "A physiological method for relaying frictional information to a human teleoperator," *IEEE Transactions on System, Man, and Cybernetics*, **23**(2):427-432, March/April 1993.
6. M. G. Allen, R. D. Howe, and R. K. Hanson, "Digital imaging of reaction zones in hydrocarbon-air flames using planar laser-induced fluorescence," *Optics Letters* **11**:126-128, 1986.
5. G. Kychakoff, R. D. Howe, R. K. Hanson, M. D. Drake, R. Pitz, M. Lapp, and C. M. Penny, "The visualization of turbulent flame fronts with planar laser-induced fluorescence," *Science* **224**:382-384, 1984.
4. G. Kychakoff, K. Knapp, R. D. Howe, and R. K. Hanson, "Flow visualization in combustion gases using nitric oxide fluorescence," *American Institute of Aeronautics & Astronautics Journal* **22**:153, 1984.
3. G. Kychakoff, R. D. Howe, and R. K. Hanson, "Quantitative flow visualization techniques for measurements in combustion gases," *Applied Optics* **23**:704-712, 1984. Also presented at the Ninth

International Colloquium on Explosions and Reactive Systems, Poitiers, France, July 1983, and reprinted in R. N. Hindy and J. H. Hunt, eds, *Selected Papers on Laser Beam Diagnostics*, SPIE Milestone Series vol. MS 126, Bellingham, WA, SPIE Optical Engineering Press, 1996.

2. G. Kychakoff, R. D. Howe, and R. K. Hanson, "Spatially resolved combustion measurements using cross-beam saturated absorption spectroscopy," *Applied Optics* **23**:1303-1305, 1984. Also presented at the 1982 Conference on Lasers and Electro-Optics Phoenix, AZ, April 14-16, 1982.
1. G. Kychakoff, R. D. Howe, R. K. Hanson, and J. C. McDaniel, "Quantitative visualization of combustion species in a plane," *Applied Optics* **21**:3225-3227, September 15, 1982.

Refereed Conference Papers

72. Kettler DT, R.D. Plowes, Novotny PM, Vasilyev NV, del Nido PJ, and Howe RD, "An Active Motion Compensation Instrument for Beating Heart Mitral Valve Surgery," to be presented at the IEEE International Conference on Intelligent Robots and Systems (IROS) San Diego, CA, Oct. 29-Nov. 2, 2007.
26. Tavakoli M, Howe RD, "The Effect of Joint Elasticity on Bilateral Teleoperation," to be presented at the IEEE International Conference on Intelligent Robots and Systems (IROS) San Diego, CA, Oct.29-Nov.2, 2007.
70. Tadakuma R, Tadakuma K, and Howe RD, "Few D.O.F. Walking Robot with Outer-Wheels," IEEE Conference on Automation Science and Engineering (CASE), Scottsdale, AZ, USA, September 22-25, 2007.
69. Dollar AM and Howe RD, "The SDM Hand as a Prosthetic Terminal Device: A Feasibility Study," IEEE International Conference on Rehabilitation Robotics (ICORR), Noordwijk, the Netherlands, June 13-15, 2007, in press. (Best Student Paper Award)
25. Yuen SG, Rudoy D, Howe RD, Wolfe PJ, "Bayesian Changepoint Detection Through Switching Regressions: Contact Point Determination in Material Indentation Experiments," IEEE Workshop on Statistical Signal Processing, Madison, Wisconsin, August 26-29, 2007, in press.
24. Oyarzábal M, Nakatani M, Howe RD, "Vibration Enhances Geometry Perception with Tactile Shape Displays," *Proceedings of the Second World Haptics Conference (Joint Eurohaptics Conference and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems)*, Tsukuba, Japan, March 22-24, 2007, IEEE Computer Society Press, pp. 44-49.
23. Linguraru MG, Kabla A, Vasilyev NV, del Nido PJ, Howe RD, "Real-time block flow tracking of atrial septal defect Motion in 4D cardiac ultrasound," Fourth IEEE International Symposium on Biomedical Imaging, Washington, DC, April 12-15, 2007, pp. 356-359.
22. P. Novotny, J. Stoll, P. Dupont, R.D. Howe, "Real-Time Visual Servoing of a Robot Using Three Dimensional Ultrasound," *Proceedings of the IEEE International Conference on Robotics and Automation*, Rome, April 2007, pp. 2655 - 2660.
21. A.M. Dollar, R.D. Howe, "Simple, Robust Autonomous Grasping in Unstructured Environments," *Proceedings of the IEEE International Conference on Robotics and Automation*, Rome, April 2007, pp. 4693 - 4700.

20. Novotny, PM, Stoll, JA, Vasilyev, NV, Del Nido, PJ, Dupont, PE, Howe, RD, "GPU Based Real-time Instrument Tracking with Three Dimensional Ultrasound," in R. Larsen, M. Nielsen and J. Sporring, eds., *Proceedings of Medical Image Computing and Computer-Assisted Intervention – MICCAI*, Lecture Notes in Computer Science, Springer Volume 4190, pp. 58-65, Copenhagen, October 2006. (Best Student Paper Award)
19. MG Linguraru, NV Vasilyev, PJ del Nido, RD Howe, "Atrial Septal Defect Tracking in 3D Cardiac Ultrasound, in R. Larsen, M. Nielsen and J. Sporring, eds., *Proc. Medical Image Computing and Computer-Assisted Intervention – MICCAI*, Lecture Notes in Computer Science, Springer Volume 4190, pp. 596-603, Copenhagen, October 2006.
18. R. L. Feller, D.P. Perrin, and R.D. Howe, "Validation and Explanation of Waterhammer-Based Locomotion," *Proceedings of the IEEE International Conference on Robotics and Automation*, pp. 4264-4269, Orlando, FL, 2006.
17. J. Stoll, P. Novotny, R.D. Howe, and P. Dupont, "Real-time 3D Ultrasound-based Servoing of a Surgical Instrument," *Proceedings of the IEEE International Conference on Robotics and Automation*, pp. 613-618, Orlando, FL, 2006.
16. A.M. Dollar and R.D. Howe, "Joint Coupling Design of Underactuated Grippers," 30th Annual ASME Mechanisms and Robotics Conference, 2006 International Design Engineering Technical Conferences (IDETC), Philadelphia, PA, Sept. 10-13, 2006. (Best Student Design Award)
15. Wagner CR, Vasilyev N, Perrin DP, del Nido PJ, Howe RD, "Force Feedback in a Three-Dimensional Ultrasound-Guided Surgical Task," *Proceedings of the 14th International Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, Washington, DC, 2006, IEEE Computer Society Press, pp. 43- 48.
14. Dollar AM, Wagner CR. Howe RD, "Sensors for Biomimetic Robots via Shape Deposition Manufacturing," *Proceedings of the First IEEE/RAS-EMBS International Conference on Biomedical Robotics and Biomechatronics (BioRob2006)*, Pisa, Italy, 2006, IEEE Press, pp. 763- 768.
13. R.A. Beasley, and R.D. Howe, "Model-Based Error Correction for Flexible Robotic Surgical Instruments," *Robotics: Science and Systems I*, Cambridge, Massachusetts, June 2005, <http://www.roboticsproceedings.org/rss01/index.html>.
12. C.R. Wagner, D.P. Perrin, R.L. Feller, R.D. Howe, O. Clatz, H. Delingette, N. Ayache, "Integrating Tactile and Force Feedback with Finite Element Models," *Proceedings of the IEEE International Conference on Robotics & Automation*, Barcelona, April 18-22, 2005, pp. 3942–3947.
11. A.M. Dollar, A. E. Kerdok, S.G. Diamond, P.M. Novotny, and R.D. Howe, "Starting on the Right Track: Introducing Students to Mechanical Engineering with a Project-Based Machine Design Course," *Proceedings of the 2005 ASME International Mechanical Engineering Congress and Exposition (IMECE)*, Mechanical Engineering Education Symposium, IMECE2005-81929, 2005.
10. A.M. Dollar and R.D. Howe, "Design and Evaluation of a Robust Compliant Grasper using Shape Deposition Manufacturing," *Proceedings of the 2005 ASME International Mechanical Engineering Congress and Exposition (IMECE)*, Robotics panel of the Dynamic Systems and Control Division, IMECE2005-79791, 2005.
9. C.R. Wagner, R.D. Howe "Mechanisms of Performance Enhancement With Force Feedback," *Proceedings of the IEEE World Haptics Conference (First Joint Eurohaptics Conference and*

Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems), Pisa, Italy, March 18-20, 2005, pp. 21 – 29.

8. M.P. Ottensmeyer, A.E. Kerdok, R.D. Howe, S.L. Dawson, "The Effects of Testing Environment on the Viscoelastic Properties of Soft Tissues," in S. Cotin and D.N. Metaxas, eds., *Proceedings of Medical Simulation: International Symposium - ISMS 2004*, Cambridge, MA, June 17-18, 2004, *Lecture Notes in Computer Science* vol. 3078, Springer-Verlag, pp. 9-18.
7. A.M. Galea and R.D. Howe, "Liver Vessel Parameter Estimation from Tactile Imaging Information," in S. Cotin and D.N. Metaxas, eds., *Proceedings of Medical Simulation: International Symposium - ISMS 2004*, Cambridge, MA, June 17-18, 2004, *Lecture Notes in Computer Science* vol. 3078, Springer-Verlag, pp. 59-66.
6. Y. Liu, A.E. Kerdok, R.D. Howe, "A Nonlinear Finite Element Model of Soft Tissue Indentation," in S. Cotin and D.N. Metaxas, eds., *Proceedings of Medical Simulation: International Symposium - ISMS 2004*, Cambridge, MA, June 17-18, 2004, *Lecture Notes in Computer Science* vol. 3078, Springer-Verlag, pp. 67-76.
5. D.P. Perrin, A. Kwon, and R.D. Howe, "A Novel Actuated Tether Design for Rescue Robots Using Hydraulic Transients," *Proceedings of the IEEE International Conference on Robotics & Automation*, New Orleans, April 26-May 1, 2004, pp. 3482-87.
4. R.A. Beasley, R.D. Howe, and P.D. Dupont, "Kinematic error correction for minimally invasive surgical robots," *Proceedings of the IEEE International Conference on Robotics & Automation*, New Orleans, April 26-May 1, 2004, pp. 358-364.
3. R.L. Feller, C.K.L. Lau, C.R. Wagner, D.P. Perrin, R.D. Howe, "The Effect of Force Feedback on Remote Palpation," *Proceedings of the IEEE International Conference on Robotics & Automation*, New Orleans, April 26-May 1, 2004, pp. 782-88.
2. C.K.L. Lau, C.R. Wagner, and R.D. Howe, "Compliant Background Subtraction Algorithms for Tactile Rendering," *Proceedings of the 12th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, Chicago, March 27-28, 2004, IEEE Computer Society Press, pp. 32-39.
1. S.J. Lederman, R.D. Howe, R.L. Klatzky, C. Hamilton, "Force variability during surface contact with bare finger or rigid probe," *Proceedings of the 12th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, Chicago, March 27-28, 2004, IEEE Computer Society Press, pp. 154- 160.
0. A.M. Dollar and R.D. Howe, "Towards Grasping in Unstructured Environments: Optimization of Grasper Compliance and Configuration," *Proceedings of the 2003 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2003)*, Las Vegas, October 27-31, 2003, pp. 3410-3416.
- 1. A.M. Galea and R.D. Howe, Mammography Registered Tactile Imaging, in N. Ayache and H. Delingette, eds., *Proceedings of the International Symposium on Surgery Simulation and Soft Tissue Modeling - IS4TM 2003*, Juan-Les-Pins, France, June 12-13, 2003, *Lecture Notes in Computer Science* vol. 2673, Springer-Verlag, pp. 183-193.
- 2. J.M. Lee, C.R. Wagner, S.J. Lederman, and R.D. Howe, "Spatial Low Pass Filters for Pin Actuated Tactile Displays," *Proceedings of the 11th Symposium on Haptic Interfaces for Virtual Environment*

- and Teleoperator Systems*, Los Angeles, March 22-23, 2003, IEEE Computer Society Press, pp. 57-62.
- 3. R. A. Beasley and R.D. Howe, "Tactile Tracking of Arteries in Robotic Surgery," *Proceedings of the IEEE International Conference on Robotics & Automation*, Washington, DC, May 11 - 15, 2002, pp. 3801-6.
 - 4. T. Debus, T.-J. Jang, P. Dupont and R. Howe, "Multi-channel vibrotactile display for teleoperated assembly," *Proceedings of the IEEE International Conference on Robotics & Automation*, May 11 - 15, 2002, pp. 592-7.
 - 5. C. R. Wagner, N. Stylopoulos, and R. D. Howe, "The Role of Force Feedback In Surgery: Analysis of Blunt Dissection," in *Proceedings of the 10th Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems*, Orlando, March 24-25, 2002, IEEE Computer Society Press, pp. 73-79.
 - 6. S. S. Park, R. D. Howe, and D. F. Torchiana, "Virtual Fixtures for Robot-Assisted Minimally-Invasive Cardiac Surgery," in W. J. Niessen and M. A. Viergever, eds., *Proc. Fourth International Conference on Medical Image Computing and Computer-Assisted Intervention – MICCAI 2001*, Utrecht, The Netherlands, 14-17 October 2001, Lecture Notes in Computer Science Vol.1679, Springer, Berlin, p. 1419-20.
 - 7. S. Selha ,P. Dupont, R.D. Howe, and D. Torchiana, "Optimal Port Placement in Robot-Assisted Coronary Artery Bypass Grafting," in W. J. Niessen and M. A. Viergever, eds., *Proc. Fourth International Conference on Medical Image Computing and Computer-Assisted Intervention – MICCAI 2001*, Utrecht, The Netherlands, 14-17 October 2001, Lecture Notes in Computer Science Vol.1679, Springer, Berlin.
 - 8. J. P. Desai and R. D. Howe, "Towards the development of a humanoid arm by minimizing interaction forces through minimum impedance control," *Proceedings of the IEEE International Conference on Robotics & Automation*, Seoul, Korea, May 23-25, 2001, pp. 4214-4219.
 - 9. T. Debus, P. Dupont and R.D. Howe, "Automatic identification of local geometric properties during teleoperation," *Proceedings of the IEEE International Conference on Robotics & Automation*, San Francisco, April 2000, pp. 3428-3434.
 - 10. F. Lai and R.D. Howe, "Evaluating Control Modes for Constrained Robotic Surgery," *Proceedings of the IEEE International Conference on Robotics & Automation*, San Francisco, April 2000, pp. 603-609.
 - 11. F. Lai, R.D. Howe, P.A. Millman, and S. Sur, "Frame Mapping And Dexterity For Task Performance In Robotic Endoscopic Surgery," in N. Olgac, ed., *Proc. of the ASME Dynamic Systems and Control Division, ASME International Mechanical Engineering Congress and Exposition*, Nashville, Nov. 14-19, 1999, DSC-Vol. 67.
 - 12. M. Shibata and R.D. Howe, "Effect of Gloving on Perceptual and Manipulation Task Performance," in N. Olgac, ed., *Proc. of the ASME Dynamic Systems and Control Division, ASME International Mechanical Engineering Congress and Exposition*, Nashville, Nov. 14-19, 1999, DSC-Vol. 67.
 - 13. T. Debus P. Dupont, and R.D. Howe, "Automatic Property Identification via Parameterized Constraints," *Proceedings of the IEEE International Conference on Robotics & Automation*, Detroit, May 1999, pp. 1876-81.

- 14. W.J. Peine and R.D. Howe, "Do humans sense finger deformation or distributed pressure to detect lumps in soft tissue?," in R.J. Furness, ed., *Proceedings of the ASME Dynamic Systems and Control Division*, ASME International Mechanical Engineering Congress and Exposition, Anaheim, Nov. 19-20, 1998, DSC-Vol. 64, pp. 273-278.
- 15. A. M. Okamura, J. T. Dennerlein and R. D. Howe, "Vibration Feedback Models for Virtual Environments," *Proceedings of the IEEE International Conference on Robotics & Automation*, Leuven, Belgium, May 16-20, 1998, pp. 674-679.
- 16. W.J. Peine, P.S. Wellman and R. D. Howe, "Temporal bandwidth requirements for tactile shape displays," in G. Rizzoni, ed., *Proceedings of the ASME Dynamic Systems and Control Division*, ASME International Mechanical Engineering Congress and Exposition, Dallas, Nov. 15-21, 1997, DSC-Vol. 61, pp. 107-113.
- 17. J.T. Dennerlein, P. Millman, and R.D. Howe, "Vibrotactile Feedback for Industrial Telemanipulators," Sixth Annual Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, ASME International Mechanical Engineering Congress and Exposition, Dallas, Nov. 15-21, 1997, DSC-Vol. 61, pp. 189-195.
- 18. A. Z. Hajian, D. S. Sanchez, and R. D. Howe, "Drum roll: Increasing bandwidth through passive impedance modulation," *Proceedings of the IEEE International Conference on Robotics and Automation*, Albuquerque, New Mexico, April 20 - 25, 1997, pp. 2294-9. (Finalist, best student paper award.)
- 19. P. E. Dupont, T. M. Schulteis, and R. D. Howe, "Experimental Identification of Kinematic Constraints," *Proceedings of the IEEE International Conference on Robotics and Automation*, Albuquerque, New Mexico, April 20 - 25, 1997, pp. 2677-82.
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Contributed Conference Papers and Presentations

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- 60. Kerdok AE, Howe RD, Socrate S, "Viscoelastic Characterization of Perfused Liver: Indentation Testing and Preliminary Modeling," to be presented at the ASME 2007 Summer Bioengineering Conference, Keystone, Colorado, USA, 20-24 June 2007.
- 59. Diamond, S.G., Howe, R.D., Schaechter, J.D., "Effect of hypnosis on motor function and cortical activation in chronic stroke patients," 13th Annual Meeting of the Organization for Human Brain Mapping (OHBM), Chicago, June 10-14, 2007.
- 58. Dollar AM, Howe RD, "A Simple, Robust Grasping in Unstructured Environments," Third Annual New England Manipulation Symposium (NEMS), Rensselaer Polytechnic Institute, Troy, NY, June 1, 2007.
- 57. Y. Ishihara, R. Nezafat, J.V. Wylie, M.G. Linguraru, M.E. Josephson, R.D. Howe, W.J. Manning, D.C. Peters, "3D Visualization of RF ablation scarring using delayed enhanced MRI co-registered with MRA," Joint Annual Meeting of the International Society for Magnetic Resonance in Medicine and the European Society for Magnetic Resonance in Medicine and Biology, Berlin, 19-25 May 2007.
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14. D. A. Kontarinis and R. D. Howe, "A multiparameter tactile display system for teleoperation," T.B. Sheridan, ed., *Analysis, Design and Evaluation of Man-Machine Systems 1995: Postprint volume from the Sixth IFAC/IFIP/IFORS/IEA Symposium*, Cambridge, June 27-29 1995, Pergamon Press, vol. 1, pp. 83-88.
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12. W.J. Peine, D. A. Kontarinis, R. D. Howe, "A remote palpation system for minimally invasive surgery," Society for Minimally Invasive Therapy 6th International Meeting, Berlin, Germany, October 2-4, 1994 (Best poster award).
11. D. A. Kontarinis and R. D. Howe, "Tactile display of contact shape in dextrous manipulation," in *Advances in Robotics, Mechatronics, and Haptic Interfaces*, DSC-vol. 49, H. Kazerooni, J. E. Colgate, and B. D. Adelstein, eds., American Society of Mechanical Engineers Winter Annual Meeting, New Orleans, Nov. 29-30, 1993, pp. 81-88.
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6. R. D. Howe, B. B. Edin, M. R. Cutkosky and G. Westling, "Relaying friction information to a human operator for dextrous telemanipulation," SPIE Conference on Telerobotics: Cooperative Intelligent Robotics in Space, Boston, MA, November 12-14, 1991.
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3. R. D. Howe and G. Kychakoff, "Optical sensing system for thermoplastic composites forming," paper TUK48, 1986 Conference on Lasers and Electro-Optics, San Francisco, CA, June 9-13, 1986.
2. G. Kychakoff, R. D. Howe, R. K. Hanson, and K. Knapp, "Flow visualization in combustion gases using planar laser-induced fluorescence," paper No. 83-0405, American Institute of Aeronautics and Astronautics 21st Aerospace Sciences Meeting, Reno, NV, Jan. 1983.
1. G. Kychakoff, K. Knapp, R. D. Howe, and R. K. Hanson, "Quantitative flow visualization in combustion gases," paper No. 82-60, Meeting of the Western States Section of The Combustion Institute, Livermore, CA, Oct. 11-12, 1982.

Book Chapters

5. A. Z. Hajian and R. D. Howe, "Biomechanics of Manipulation: Grasping the Task at Hand," in J. Winters and P. Crago, eds, *Neural Control of Posture & Movement*, Springer-Verlag, 2000, pp.382-389.
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2. M. R. Cutkosky and R. D. Howe, "Human grasp choice and robotic grasp analysis," in S. T. Venkataraman and T. Iberall, eds., *Dextrous Robot Hands*, New York, Springer-Verlag, 1990.
1. M. R. Cutkosky, P. Akella, R. D. Howe, and I. Kao, "Grasping as a contact sport," in R. Bolles and B. Roth, eds., *Robotics Research*, Cambridge, MIT Press, pp. 199-206, 1987.

Other Publications and Presentations

D.P. Perrin and R.D. Howe, "Actuated tether," U.S. Patent No. 7,255,192, August 14, 2007.

"Tactile Feedback in Telemanipulation," *Video proceedings of the IEEE International Conference on Robotics & Automation*, New Orleans, April, 2004.

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“Robotic Surgery – The Healing Touch,” video exhibit, Museum of Science, Boston.

R. D. Howe and R. E. Kronauer, “Thomas McMahon: A Dedication In Memoriam,” *Annual Review of Biomedical Engineering* vol. 3, 2001.

P.S. Wellman, J.S. Son, R.D. Howe, “System generating a pressure profile across a pressure sensitive membrane,” U.S. Patent No. 5,983,727, November 16, 1999.

“Robots, surgery, and the sense of touch,” Harvard University Science Center Research Lecture, April 19, 1995.

Invited testimony, Hearing on the Future of Research-Intensive Universities and Their Relationship with the Federal Government, President’s Council of Advisors on Science and Technology, Dr. D. Allan Bromley, Chair, Massachusetts Institute of Technology, June 24, 1992.

R.D. Howe and G. Kychakoff, “Fiber-optic Inverse-square Displacement Sensor,” U.S. Patent No. 4,865,443, September 12, 1989.

Invited Presentations (Past seven years)

“Ultrasound Guidance for Beating-Heart Surgery” Mechanical Engineering Department, Massachusetts Institute of Technology, November 3, 2006.

“Image Processing for 3D Ultrasound-Guided Beating-Heart Surgery” CIMIT Forum, Massachusetts General Hospital, June 6, 2006.

“Image Processing for 3D Ultrasound-Guided Beating-Heart Surgery,” Surgical Planning Lab, Brigham and Women's Hospital, February 15, 2006.

“Robots in the OR,” Emerson Hospital, Concord, MA, June 25, 2004.

“Tactile Displays: The Shape of Things to Come,” Keynote Address, EuroHaptics Conference , Munich, June 5, 2004.

“Tactile Shape Displays,” International Scientific Workshop on Tactile stimulators: Technology and Uses, IRCICA/Institut d'Electronique, de Microélectronique et de Nanotechnologie/Université des Sciences et Technologies de Lille, Villeneuve d'Ascq, France, March 23, 2004.

“Quantitative Touch: Medical Applications of Tactile Imaging and Tactile Display,” Department of Mechanical Engineering and Mechanics Distinguished Seminar Presentation, Drexel University, January 9, 2004.

“Haptics and Force Feedback for Surgery ,” Engineering the Future of Surgery: A Symposium for Engineers and Surgeons, Columbia University, April 8, 2002.

“Quantified touch: Tactile imaging and display in medicine” Department of Mechanical Engineering, University of Michigan, January 25, 2002.

“Tactile displays: Design, psychophysics, and rendering algorithms,” Workshop on Haptics, Virtual Reality and Human Computer Interaction, Institute for Mathematics and Applications, University of Minnesota, Minneapolis, June 14-15, 2001.

“Modeling by Manipulation,” Department of Electronics, Computer Science and Systems, University of Bologna, Italy, March 29, 2001.

“Modeling by Manipulation,” Department of Mechanical Engineering, Johns Hopkins University, March 8, 2001.

“Modeling by Manipulation,” GRASP Laboratory, University of Pennsylvania, March 8, 2000.

“Virtual Fixtures for Robot-Assisted Minimally-Invasive Cardiac Surgery,” Center for Innovative Minimally Invasive Therapies, Massachusetts General Hospital, February 15, 2000.

“Tactile Imaging and Remote Palpation,” Center for Innovative Minimally Invasive Therapies, Massachusetts General Hospital, December 7, 1999.

“Remote Palpation,” Robotics and Intelligent Machines Laboratory, University of California at Berkeley, May 27, 1999.

“Tactile Imaging, Tactile Display, and Surgical Simulation,” Department of Electrical and Computer Engineering, University of Colorado, April 21, 1999.

TEACHING

Engineering Sciences 51: Computer-Aided Machine Design.

Undergraduate course on the design and construction of mechanical and electromechanical devices. Extensive laboratory use of CNC machine tools. Typical enrollment 25.

Engineering Sciences 125: Mechanical Systems.

Undergraduate course in modeling and analysis of mechanical and electromechanical systems, including linear systems and introduction to rigid-body mechanics, with several laboratory experiments. Typical enrollment 20.

Engineering Sciences 96, 100: Engineering Design (co-taught).

Project-based courses on the process and practice of engineering design. Students in the junior year course (Eng. Sci. 96) work in teams of 4 to 6; in the senior year course (Eng. Sci. 100) they pursue an individual project. Typical enrollment 25.

Engineering Sciences 149: Muscles, Reflexes, and Locomotion.

Phenomenology and mathematical modeling of neuromuscular systems, including crossbridge models of muscle, neural control and reflexes, and energy considerations in walking and running. Typical enrollment 10.

Engineering Sciences 159/259, Introduction to Robotics.

Undergraduate/graduate courses on robot manipulators, including kinematics, dynamics, sensing, and control. Laboratory experiments on industrial robot programming, kinematics, and simulation of manipulator dynamics. Typical enrollment 12.

Engineering Sciences 258: Robot Mechanics.

Advanced graduate course on robot design, control, sensing, and manipulation, including multifingered hands. Typical enrollment 5.

STUDENT SUPERVISION

Ph.D. RESEARCH SUPERVISION

Completed

- Dimitri A. Kontarinis, *Tactile Displays for Dextrous Telem Manipulation*, 1995 (Current position and organization: Chief Information Officer, ELBISCO Group, Athens, Greece).
- Jae S. Son, *Integration of Tactile Sensing and Robot Hand Control*, 1996 (Founder and CEO, Pressure Profile Systems).
- Dianne T. V. Pawluk, *A Viscoelastic Model of the Human Fingerpad and a Holistic Model of Human Touch*, 1997 (Asst. Prof., Virginia Commonwealth University).
- Aram Z. Hajian, *A Characterization of the Mechanical Impedance of Human Hands*, 1997 (Consultant, Exponent Consulting, Philadelphia).
- William J. Peine, *Remote Palpation Instruments for Minimally Invasive Surgery*, 1998 (Asst. Prof., Purdue University).
- Parris S. Wellman, *Tactile Imaging*, 1999 (Engineering director, Helicos BioSciences Corporation).
- Heather E. Gunter (Moss), *Mechanical Stress in Vocal Fold Tissue During Voice Production*, 2003 (Resident, Department of Neurology, Hospital of the University of Pennsylvania).
- Anna M. Galea, *Mapping Tactile Information: Parameter Estimation and Deformable Registration*, 2003 (Staff scientist, InfoSciTex Corp., Waltham, Mass.).
- Solomon G. Diamond, *Cognitive Effects on the Neurophysiology and Biomechanics of Stroke Recovery*, 2004 (Asst. Prof., Dartmouth College).
- Thomas Debus (Boston University), *Modeling By Manipulation – Enhancing Robot Perception Through Contact State Estimation*, 2005 (Engineer, Alliance Spacesystems Inc., Pasadena, Calif.).
- Christopher R. Wagner, *Force Feedback in Surgery: Physical Constraints and Haptic Information*, 2006 (Staff scientist, Cybernet Systems, Ann Arbor, Mich.).
- Amy E. Kerdok, *Characterizing the Nonlinear Mechanical Response of Liver to Surgical Manipulation*, 2006 (Clinical development engineer, Intuitive Surgical, Sunnyvale, Calif.).
- Ryan A. Beasley *Model-Based Error Correction for Instrument Flexion in Robotic Surgery*, 2006 (Asst. Prof., Texas A&M University)
- Aaron Dollar, *Design Principles for Robust Grasping in Unstructured Environments*, 2006 (Postdoctoral Associate, MIT).
- Paul Novotny, *Real-Time Processing of Three Dimensional Ultrasound for Intracardiac Surgery*, 2007 (Postdoctoral Associate, Children's Hospital Boston)

In progress

- Petr Jordan, Thesis area: Tissue mechanics
- Shelten Yuen, Thesis area: Image-guided surgery
- Yuri Ishihara, Thesis area: Image-guided procedures
- Peter Hammer (Tufts University), Thesis area: Mechanics-based surgical planning

Ph.D. THESIS COMMITTEE CHAIR

Cecile Smeesters, "Fall Biomechanics and Hip Fracture Risk," August 1999 (Sherbrooke University).

M.S. STUDENT RESEARCH SUPERVISION

Eric Dunn, Research area: Smooth robotic walking, 1993 (Current organization: Quantum Corp.).

Gregg Favalora, 1998 (Actuality Systems).

Dimitrios Hristu-Varsakelis, Research area: Teleoperation, 1994 (University of Macedonia, Greece).

Mei Shibata, Research area: Tactile perception, 1999 (Braun Consulting).

Fuji Lai, Research area: Robotic surgery, 2000 (Aptima, Inc.).

POST DOCTORAL FELLOWS

Paul A. Millman (Ph.D. Northwestern University) 1995-1996 (Engineer, Intuitive Surgical)

Research area: Haptic interfaces and teleoperation

Jack T. Dennerlein (Ph.D. UC Berkeley) 1996 – 1998 (Assoc. Prof., Harvard University School of Public Health)

Research area: Vibrotactile perception and feedback

Jaydev Desai (Ph.D. University of Pennsylvania) 1998-1999 (Assoc. Prof., University of Maryland)

Research area: Robotic manipulation

Yoky Matsuoka (Ph.D. MIT) 1998-2000 (Assoc. Prof., University of Washington)

Research area: Human limb impedance and learning

Shinsuk Park (Ph.D. MIT) 2000-2002 (Assist. Prof., Korea University)

Research area: Image-guided robotic cardiac surgery

Douglas P. Perrin (Ph.D. University of Minnesota) 2002-2005 (Staff Scientist/Instructor, Children's Hospital Boston/Harvard Medical School)

Research area: Medical image processing

Marius G. Lingararu (Ph.D. Oxford University) 2004-2006 (Staff Scientist, National Institutes of Health)

Research area: Medical image processing

Riichiro Tadakuma (Ph.D. University of Tokyo) 2006-present

Research area: Tactile displays

Mahdi Tavakoli, (Ph.D. University of Western Ontario) 2007-present

Research area: Surgical robotics