Russell H. Taylor

PERSONAL DATA

Current Positions	John C. Malone Professor of Computer Science with joint appointments in Radiology, Mechanical Engineering and Surgery Director, Laboratory for Computational Sensing and Robotics Director, NSF Engineering Research Center for Computer-Integrated Surgical Systems and Technology (graduated center) 127 Hackerman Hall The Johns Hopkins University 3400 North Charles Street Baltimore, Maryland 21218
Office Phone	410-516-6299
Fax	410-516-5553
Email	rht@jhu.edu
Web Pages	http://cs.jhu.edu/~rht/ Lab Web Page: http://ciis.lcsr.jhu.edu/

EDUCATION

1970 The Johns Hopkins University B.E.S. (Interdepartmental)

Interdepartmental major with concentration in Operations Research & Computer Science

1976 Stanford University Ph.D. (Computer Science)

Dissertation research, *The Synthesis of Manipulator Control Programs from Task-Level Specifications,* developed methods for automatic programming of sensor-based robot programs for mechanical assembly tasks.

WORK HISTORY

2013-now	Johns Hopkins University	Director, Laboratory for Computational Sensing and Technology (LCSR)
1998-now	Johns Hopkins University	Director, [Graduated] NSF Engineering Research Center for Computer-Integrated Surgical Systems and Technology (CISST ERC)
1995-now	Johns Hopkins University	John C. Malone Professor of Computer Science with joint appointments in Radiology, Mechanical Engineering, and Surgery
1990-95	IBM Research	Manager of Computer Assisted Surgery
1989-90	IBM Research	Research Staff Member
1987-89	IBM Research	Manager of Automation Technology
1982-87	IBM Research	Manager of Robot Systems and Technology
1982	IBM Research	Visiting Scientist at MIT Al Lab
1980-82	IBM Research	Research Staff Member
1978-79	IBM Boca Raton	Advisory Engineer
1976-77	IBM Research	Research Staff Member
1970-76	Stanford University	Research Assistant
1968-70	Johns Hopkins University	Research Assistant

Note: Fuller summaries of experience appear below.

AWARDS and HONORS

1. Elected to **The National Academy of Engineering** (2020) "for contributions to the development of medical robotics and computer-integrated systems."
2. The **Honda Prize** "for his tremendous contributions in the development of medical robots, technological evolution in this field, and producing highly skilled technical personnel" (2015)
3. **IEEE Engineering in Medicine and Biology Society Technical Field Award "**for contributions and leadership in the field of surgical robotics and computer-integrated interventional systems" (2015)
4. **National Academy of Inventors** (**Member** 2015; **Fellow** 2017) based on my "impressive volume" of issued U.S. Patents while working at JHU.
5. **John C. Malone Professorship** in the Johns Hopkins University Whiting School of Engineering in recognition of leadership and accomplishment in multidisciplinary research (2011).
6. **Medical Image Computing and Computer Assisted Surgery (MICCAI) Society Enduring Impact Award** (2010)
7. **Medical Image Computing and Computer Assisted Surgery (MICCAI) Society Fellow** (2009)
8. **Fellow of the Engineering School of the University of Tokyo** (2009)
9. **IEEE Robotics and Automation Society Pioneer Award** "for pioneering work in medical robotics and in the theory and practice of programmable automation systems" (2008)
10. **Maurice E. Mueller Award for Excellence in Computer Assisted Surgery** (2000)
11. **IEEE Third Millennium Medal** (2000)
12. **IEEE Fellow** (elected 1994) for technical contributions and leadership in the theory and implementation of programmable sensor-based robot systems and their application to surgery and manufacturing.
13. **AIBME Fellow** (elected 1998)
14. **IBM Outstanding Technical Achievement Award** (1993) and **IBM Group Achievement Award** (1991) for "Robodoc" system for Hip Replacement Surgery.
15. **IBM Outstanding Technical Achievement Award** (1984) and two **Outstanding Contribution Awards** (1982,1987) for development and transfer into productive use of AML language.
16. **IBM Invention Awards** (1983, 1991, 1992, 1994)

PROFESSIONAL ACTIVITIES

Editorial boards

1. *IEEE Trans. on Robotics and Automation* (1985-now, Editor in Chief: 1988-1994; Editor in Chief Emeritus 1995-now)
2. *International Journal of Robotics Research* (1986-2009; Advisory Board Member, 2009-now)
3. *Computer Aided Surgery* (1995-2005)
4. *Medical Image Analysis* (1996-2009)
5. *IEEE Transactions on Medical Imaging* (Associate Editor, 2011-now)
6. *AAAS Science Robotics* (Advisory Board Member, 2016-2020)
7. *International Journal of Computer Assisted Radiology and Surgery* (Deputy Editor, 2015-now)
8. *Advanced Biomedical Engineering*, Japanese Society for Medical and Biomedical Engineering (2015-now)
9. *Biosystems & Biorobotics*, Springer Book Series (2012-now)
10. *IEEE Transactions on Medical Robotics and Bionics* (Editor for Surgical Robotics, 2018-now)
11. *Computer Assisted Surgery* (2020-now)
12. *IEEE Proceedings* (Chief Editor of Special Issue on Surgical Robotics, 2022)

Selected conference and workshop committees

1. *Medical Robotics and Computer Assisted Surgery* (**Program chair**, 1994; **general chair** 1995; Organizing committee 1997)
2. *Medical Image Computing & Computer-Assisted Interventions (MICCAI)* – **Organizing/Steering Committee** (1998-2002)
3. *NSF Workshop on Computer-Assisted Surgery* (co-organizer and program chair, Mar 1993)
4. *MediMech 92* (Program chair, Oct. 1992)
5. *IEEE Int. Conference on Robotics and Automation* (1987-1994; 2001-2004; ...)
6. *Int. Workshop on Deformable Modeling and Soft Tissue Simulation* (2001)
7. *Computer-Assisted Radiology & Surgery (CARS) 2002*
8. *Computer Assisted Surgery for the Head (CAS-H), Conference Advisory Board, Bern, Switzerland, 2004*
9. **Conference Review Committee Member,** *IEEE International Conference on Robotic Systems (IROS)*
10. **Organizer**, *Winter School on Medical Robotics and Computer-Integrated Interventional Systems,* Johns Hopkins University, Jan 12-16, 2009.
11. **Program committee member**, *Medical Image Computing and Computer-Assisted interventions (MICCAI)*, London; PC Meeting 5/17-18, 2009; Conference 9/21-23/2009.
12. **Organizer**, *Tutorial on Medical Robotics*; MICCAI, London, 9/20/2009.
13. **Executive Committee Member**, *Information Processing in Computer-Assisted Intervention (IPCAI)*; 2010-now.
14. **Program chair,** *Information Processing in Computer-Assisted Intervention (IPCAI)*; Berlin, June, 2011.
15. **Program committee member**, *Medical Image Computing and Computer-Assisted interventions (MICCAI)*, Toronto, PC Meeting May 2011, Conference 9/19-23.
16. **Program committee member**, *Hamlyn Symposium on Medical Robotics*, London, June 2011.
17. **Program committee member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Pisa, June, 2012.
18. **Program committee member**, *Hamlyn Symposium on Medical Robotics*, London, July 2012.
19. **Program committee member**, *Medical Image Computing and Computer-Assisted interventions (MICCAI)*, Nice, September 2012.
20. **Program committee member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Heidelberg, Germany, June 2013.
21. **Program committee member**, *Hamlyn Symposium on Medical Robotics*, London, July 2013.
22. **Program committee member**, *Medical Image Computing and Computer-Assisted interventions (MICCAI)*, Nagoya, September, 2013.
23. **Program committee member**, *Hamlyn Symposium on Medical Robotics*, London, June 2014.
24. **Program Committee member**, *International Conference on Robotics and Automation*, Hong Kong, 2014.
25. **Program Committee member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Fukuota, Japan, June 2014.
26. **Steering Committee member,** *Hamlyn Robotics Challenge,* London, 2015.
27. **Program Committee member**, *Hamlyn Symposium on Medical Robotics*, London, June 2015.
28. **Program Board member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Barcelona, June 2015.
29. **Program Committee member**, *Hamlyn Symposium on Medical Robotics*, London, June 2016.
30. **Best Medical Robotics Paper Award Committee member,** *IEEE Robotics and Automation Conference,* June 2016.
31. **Organizing Committee member,** *JHU Surgery Innovation Symposium,* September 2016,
32. **Program Committee member**, *Medical Imaging and Augmented Reality*, August 2016.
33. **Program Board member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Heidelberg, 2016.
34. **Program Committee member**, *Hamlyn Medical Robotics Challenge*, London, June 2017., 2018
35. **Steering Committee member**, *AAAS Halcyon Dialogs on Robotics*, 2016-2017.
36. **Awards Committee member**, Best Medical Robotics Paper, *IEEE Int. Conf. on Robotics and Automation*, Singapore, May 30, 2017.
37. **Awards Committee member**, Pioneer in Robotics selection panel. *IEEE Robotics and Automation Society,* 2017.

38. **Program Board member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Barcelona, June 2017.
39. **Program Committee Member**, *IEEE Int. Conf. on Intelligent Robots and Systems (IROS)*, Vancouver, September 2017.
40. **Steering Committee Member,** *Information Processing in Computer-Assisted Intervention (IPCAI),* June 2018.
41. **Program Committee Member,** *Hamlyn Symposium on Medical Robotics*, London, June 2018
42. **Co-organizer**, *First-in-Human Workshop*, at the *Hamlyn Symposium on Medical Robotics*, London, June 2018.
43. **Program Committee Member,** *MICCAI Workshop on Context-Aware Operating Rooms*, Grenada, October 2018
44. **Steering Committee Member,** *Information Processing in Computer-Assisted Intervention (IPCAI),* June 2019.
45. **Co-organizer**, *First-in-Human Workshop*, at the *Hamlyn Symposium on Medical Robotics*, London, June 2019
46. **Program Committee Member,** *Hamlyn Symposium on Medical Robotics*, London, June 2019
47. **Steering Committee Member,** *Hamlyn Surgical Robotics Challenge*, virtual meeting, 2020-2021
48. **Program Committee Member,** *Hamlyn Symposium on Medical Robotics*, virtual meeting, 2020-2022
49. **Program Board Member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, virtual meeting, 2020.
50. **Program Committee Member**, *AI-CAI, CARE, and OR 2.0 Joint MICCAI Workshop*, virtual meeting 2020.
51. **Organizing Committee,** *2023 IEEE Robotics and Automation Conference (ICRA),* 2020-now.
52. **General co-Chair***, 2023 Medical Imaging and Computer-Assisted Intervention Conference (MICCAI)*, 2020-now.
53. **Program Committee Member**, *Computer Assisted Radiology and Surgery Conference (CARS)*, June 2021.
54. **Program Board Member,** *Information Processing in Computer-Assisted Intervention (IPCAI)*, Munich, June 2021.
55. **Co-organizer,** *ASMUS 2021: The 2nd International Workshop on Advances in Simplifying Medical Ultrasound*, September 2021

Selected other external committees and advisory boards

1. **Advisory Committee,** NSF Div. of Information, Robotics and Intelligent Systems (1988-1991)
2. **Administrative Committee**, IEEE Robotics and Automation Society (1987-1994)
3. National Research Council; Japan Society for Promotion of Science Panel on Bilateral Exchange on Approaches to Robotics in the United States and Japan (1989)
4. **Advisory Panel**, NSF Robotics and Human Augmentation (2001-2003)
5. **Advisory Board**, Ontario Consortium for Image-Guided Therapy and Surgery (2001-2003)
6. **Medical Image Computing and Computer-Aided Interventions Society, Founding Member of Society Board**, 2003-2004
7. **Computer-Assisted Orthopaedic Surgery, Standards Committee Member***, 2004*
8. **External Advisory Board***,* Mechanical Engineering Department, Columbia University (2009-2016)
9. **External Advisory Board**, Center for Image-Guided Innovation and Therapeutic Intervention at Toronto Children's Hospital (2012-now)
10. **External Advisory Board**, Institut de Chirurgie Mini-Invasive Guidée par L'Image, IHU Strasbourg (2012-2020)
11. **External Advisory Board***,* Computer Assisted Surgery Laboratory of Excellence in Grenoble (Board President, 2012-now)
12. **President's Advisory Board,** Daegu Gyeongbuk Institute of Science and Technology**,** Daegu, Korea (2012-2014)
13. **Standing Committee of External Evaluators for Robotics**, Italian Institute of Technology (2012-now)
14. ***Ad hoc* Strategic Advisory Board Member**, Boston Children's Hospital (2013)

15. **Steering Committee Member,** Information Processing and Computer Assisted Surgery (www.ipcai.org) (2011-now)
16. **External Advisory Committee**, Robotics Engineering Department, Daegu Gyeongbuk Institute of Science and Technology**,** Daegu, Korea (2015-2017)
17. **International Advisory Committee**, Center for Bionics, Biomedical Research Institute, Korean Institute for Science and Technology, 2016
18. **Executive Committee Member**, Malone Center for Engineering in Healthcare, Johns Hopkins University (2016-now)
56. **Award Committee Member,** IEEE Robotics and Automation Society Pioneer Award (2016)
57. **Award Committee Member,** IEEE Edison Award (2018-2021)
58. **External Advisory Committee,** EPSRC programme grant Micro-Robotics for Surgery, Imperial College (2018-now)
59. **Technical Advisory Board**, Galen Robotics (2016-2023)
60. **International Advisory Board,** EPSRC Centre for Interventional and Surgical Sciences (WEISS), University College, London (2019-now)
61. **International Advisory Board,** Multi-Scale Medical Robotics Centre, Chinese University of Hong Kong (2021-now)
62. **Competition Judge,** *EPSRC UK-RAS Medical Robotics for Contagious Diseases Challenge 2020,2021*.
63. **Review Panel Member,** *NRC Research Associateship Programs* (2022)
64. **Scientific Advisory Board Member**, Multi-Scale Medical Robotics Centre, Hong Kong (2022-now)

(Numerous other committees and advisory boards over the past 30 years)

PUBLICATIONS

Books

1. Taylor, R.H., S. Lavallee, G. Burdea, and R. Mosges, eds. *Computer-Integrated Surgery*, 1996, MIT Press: Cambridge, Mass.

Book Chapters & Sections

1. Lozano-Perez, T. and R. Taylor, "Geometric Issues in Planning Robot Tasks", in *Robotics Science*, M. Brady, Editor. 1989, MIT Press.
2. Cutting, C.B., F.L. Bookstein, and R.H. Taylor, "Applications of Simulation, Morphometrics and Robotics in Craniofacial Surgery", in *Computer-Integrated Surgery*, R.H. Taylor, et al., Editors. 1996, MIT Press: Cambridge, Mass. p. 641-662.
3. R. H. Taylor, "Safety". in *Computer-Integrated Surgery*, R. H. Taylor, S. Lavallee, G. Burdea, and R. Mosges, Eds. Cambridge, Mass.: MIT Press, 1996, pp. 283-286.
4. Taylor, R. H. (1999). "Medical Robotics". *Handbook of Industrial Robotics*, Second Edition. S. Y. Nof. New York, Wiley: 1213-1230.
5. Taylor, R. H., "Robotics in Orthopaedic Surgery", *Computer-Assisted Orthopaedic Surgery*, Nolte & Ganz, eds. Seattle, Hogrefe & Huber, pp 35-41.
6. Taylor, R. H. and L. Joskowicz, "Computer-Integrated Surgery and Medical Robotics", in *Standard Handbook of Biomedical Engineering and Design*, M. Kutz, Editor. 2002, McGraw Hill.
7. R. H. Taylor, "Robotic Systems for Orthopaedic Surgery," in *Computer and Robotic Assisted Knee and Hip Surgery*, A. DiGioia, B. Jaramaz, F. Picard, and L. P. Nolte, Eds., Oxford Press, 2004, pp. 67-78.
8. R. H. Taylor, "Medical Robotics," in *Computer and Robotic Assisted Knee and Hip Surgery,* A. DiGioia, B. Jaramaz, F. Picard, and L. P. Nolte, Eds., Oxford Press, 2004, pp. 54-59.
9. N. Simaan, R. Taylor, A. Hillel, and P. Flint, "Minimally Invasive Surgery of the Upper Airways: Addressing the Challenges of Dexterity Enhancement in Confined Spaces," in *Surgical Robotics – History, Present and Future Applications*, R. Faust, Ed.: Nova Science Publishing, 2007, pp. 223-242.

10. Li, M., A. Kapoor, R.H. Taylor. "Telerobot Control by Virtual Fixtures for Surgical Applications." Chapter in: *Advances in Telerobotics Human Interfaces, Bilateral Control and Applications*. Manuel Ferre, Martin Buss, Rafael Aracil, Claudio Melchiorri and Carlos Balaguer (Eds.) Springer Verlag, 2007, pp 381-401.
11. Taylor, R.H., P. Kazanzides."Medical Robotics and Computer-Integrated Interventional Medicine." In *Biomedical Information Technology.* Academic Press, 2007, pp. 393-416.
12. R. Taylor, A. Menciassi, G. Fichtinger, and P. Dario, "Medical Robotics and Systems", *Handbook on Robotics: Springer*, 2008, pp. 1199-1222.
13. R. H. Taylor and P. Kazanzides, "Medical Robotics and Computer-Integrated Interventional Medicine," in *Advances in Computers*. vol. 73, M. Zelkowitz, Ed.: Elsevier, 2008, pp. 217-258.
14. R. Taylor, A. Menciassi, G. Fichtinger, and P. Dario, "Medical Robotics and Computer-Integrated Surgery", *Handbook on Robotics: Springer, 2nd Edition*, 2016.
15. W. P. Liu, J. D. Richmon, J. M. Sorger, M. Azizian, and R. H. Taylor, "Intraoperative imaging and navigation in robotic surgery". in *Atlas of Head and Neck Robotic Surgery*, Z. Gil, M. Amit, and M. E. Kupferman, Eds.: Springer, 2017, p.201-213.
16. M. Armand, R. Grupp, Ryan Murphy, R. Hegman, R. Armiger, Russell Taylor, B. McArthur, and J. Lepisto, "Biomechanical Guidance System for Periacetabular Osteotomy". in *Intelligent Orthopaedics, Advances in Experimental Medicine*, G. Zheng, W. Tian, and X. Zhuang, Eds. Singapore: Springer Nature, 2018, pp. 169-179.
17. W. P. Liu and R. H. Taylor, "Augmented Reality in Image-Guided Robotic Surgery". in *Mixed and Augmented Reality in Medicine,* T. M. Peters, C. A. Linte, Z. Yaniv, and J. Williams, Eds.: CRC Press, 2018.
18. R. H. Taylor, P. Kazanzides, G. Fischer, and N. Simaan, "Medical Robotics and Computer-Integrated Interventional Medicine". in *Biomedical Information Technology*, D. Feng, Ed.: Elsevier, 2019.
19. R. H. Taylor, "Foreword". in *Handbook-of-Robotic-and-Image-Guided-Surgery*, M. H. Abedin-Nasab, Ed.: Elsevier, 2019.
20. R. H. Taylor, "Computer-integrated interventional medicine: A 30 year perspective". Chapter 25, p. 599-624 in *Handbook of Medical Image Computing and Computer Assisted Intervention*, D. Rueckert, K. Zhou, and Gabor Fichtinger, Eds.: Elsevier, 2020.

Published Refereed Reviews

1. Taylor, R.H., "Review of 'MH-1: a Computer Operated Mechanical Hand:', by H.A. Ernst", in Robotics Reviews, O. Khatib, Editor. 1989, MIT Press: Cambridge.
2. Taylor, R.H., "Review of 'Robots in Service', by J. Engleberger", in Robotics Reviews II, O. Khatib, Editor. 1991, MIT Press: Cambridge

Refereed Journal Articles

1. Grossman, D.D. and R.H. Taylor, "The Interactive Generation of Object Models with a Manipulator." *IEEE Trans. on Systems, Man, and Cybernetics*, 1978, SMC-8 (9): p. 667-679.
2. Taylor, R.H., "The Planning and Execution of Straight Line Manipulator Trajectories." *IBM Journal of Research and Development*, 1979, 23(4): p. 424-436.
3. Taylor, R.H., P.D. Summers, and J.M. Meyer, "AML, A Manufacturing Language." *Int. Journal. of Robotics Research*, 1982, 1(3): p. 19-41.
4. Taylor, R.H. and D.D. Grossman, "An Integrated Robot Systems Architecture." *IEEE Proceedings*, 1983, 71(7): p. 842-857.
5. Lozano-Perez, T., M.T. Mason, and R.H. Taylor, "Automatic Synthesis of Fine-Motion Strategies for Robots" *Int. J. Robotics Res*, 1984, 3(1): p. 3-24.
6. Nackman, L.R. and R.H. Taylor, "An Hierarchical Exception Handler Binding Mechanism." *Software Practice and Experience*, 1984, 14(10): p. 999-1003.
7. Taylor, R.H., R.L. Hollis, and M.A. Lavin, "Precise Manipulation with Endpoint Sensing." I*BM Journal of Research and Development*, 1985, 29(5): p. 363-377.
8. Funda, J., R.H. Taylor, and R.P. Paul, "On Homogeneous Transforms, Quaternions, and Computational Efficiency." *IEEE Transactions on Robotics and Automation*, 1990, 6(3 (June)): p. 382-387.

9. Taylor, R.H., R.P. Paul, B.D. Mittelstadt, et al, "An Image-Based Robotic System for Hip Replacement Surgery," *J. Robotics Society of Japan*, 1990, 8(5): p. 111-116.
10. H. Paul, W. Bargar, B. Mittelstadt, B. Musits, R. Taylor, P. Kazanzides, J. Zuhars, B. Williamson, and W. Hansen, "Development of a Surgical Robot for Cementless Total Hip Arthroplasty", *Clinical Orthopaedics and Related Research*, vol. 285-, pp. 57-66, Dec 1992.
11. Taylor, R.H., H.A. Paul, C.B. Cutting, B. Mittelstadt, W. Hanson, P. Kazanzides, B. Musits, Y.-Y. Kim, A. Kalvin, B. Haddad, D. Khoramabadi, and D. Larose, "Augmentation of Human Precision in Computer-Integrated Surgery." *Innovation et Technologie en Biologie et Medicine*, 1992, 13(4 (special issue on computer assisted surgery)): p. 450-468.
12. Taylor, R.H., H.A. Paul, P. Kazandzides, B.D. Mittelstadt, W. Hanson, J.F. Zuhars, B. Williamson, B.L. Musits, E. Glassman, and W.L. Bargar, "An Image-directed Robotic System for Precise Orthopaedic Surgery." *IEEE Transactions on Robotics and Automation*, 1994, 10(3): p. 261-275.
13. Taylor, R.H., J. Funda, B. Eldridge, K. Gruben, D. LaRose, S. Gomory, M. Talamini MD, L. Kavoussi MD, and J. Anderson, "A Telerobotic Assistant for Laparoscopic Surgery." *IEEE EMBS Magazine*, 1995, 14(3): p. 279-291.
14. J. Anderson, R. Taylor, S. Schreiner, M. Choti, E. Fishman, and G. Anderson, "Image-Guided Percutaneous Robotic Assisted Therapy", *Annals of Biomedical Engineering*, vol. 24- Supp 1, pp. S-71, October 1996
15. Eldridge, B., K. Gruben, D. LaRose, J. Funda, S. Gomory, J. Karidis, G. McVicker, R. Taylor, and J. Anderson, "A Remote Center of Motion Robotic Arm for Computer Assisted Surgery." *Robotica*, 1996, 14(1): p. 103-109.
16. Kalvin, A.D. and R.H. Taylor, "Superfaces: Polygonal Mesh Simplification with Bounded Error." *IEEE Computer Graphics and Applications*, 1996, 16(3): p. 64-77.
17. Joskowicz, L. and R.H. Taylor, "Interference-Free Insertion of a Solid Body into a Cavity: An Algorithm and a Medical Application." *Int Journal of Robotics Research,* 1996, 15(3): p. 211-229.
18. Taylor, R.H., J. Funda, L. Joskowicz, A. Kalvin, S. Gomory, A. Gueziec, and L. Brown, "An Overview of Computer-Integrated Surgery Research at the IBM T. J. Watson Research Center." *IBM Journal of Research and Development*, 1996, 40(2): p.163-183.
19. Funda, J., R. Taylor, B. Eldridge, S. Gomory, and K. Gruben, "Constrained Cartesian motion control for teleoperated surgical robots." *IEEE Transactions on Robotics and Automation*, 1996, 12(3), p. 453-466.
20. Caddedu, J.A., A. Bzostek, S. Schreiner, A. Barnes, W.W. Roberts, J.H. Anderson, R.H. Taylor, and L.R. Kavoussi, "A Robotic System for Percutaneous Renal Access." *Urology*, 1997, 158(4): p. 1589-1593.
21. Gueziec, A., P. Kazanzides, B. Williamson, and R. Taylor, "Anatomy-Based Registration of CT-Scan and Intraoperative X-Ray Images for Guiding a Surgical Robot." *IEEE Transactions on Medical Imaging*, 1998, 17(5): p. 715-728. PMID: 9874295.
22. Taylor, R.H., L. Joskowicz, B. Williamson, et al., "Computer-Integrated Revision Total Hip Replacement Surgery: Concept and Preliminary Results." *Medical Image Analysis*, 1999, 3(3): p. 301-319.
23. Poulose, B., M. Kutka, M.M. Sagaon, et al., "Human Versus Robotic Organ Retraction During Laparoscopic Nissen Fundoplication." *Surgical Endoscopy*, 1999, 13: p. 461-465.
24. Sadegh, P., F. Mourtada, R. Taylor, and J. Anderson, "Brachytherapy Optimal Planning with application to Intravascular Radiation Therapy." *Medical Image Analysis*, 1999, 3(3): p. 223-236.
25. Taylor, R., P. Jensen, L. Whitcomb, et al., "A Steady-Hand Robotic System for Microsurgical Augmentation". *International Journal of Robotics Research,* 1999. 18(12): p. 1201-1210 (Invited Paper).
26. Taylor, R.H., G. Fichtinger, P. Jensen, and C. Riviere, "Medical Robotics and Computer-Integrated Surgery: Information-driven Systems for 21st Century Operating Rooms." *Japanese Journal of Computer-Assisted Surgery*, 2000, 2(2): p. 47-53 (Invited Paper).
27. Yao, J., R.H. Taylor, R.P. Goldberg, et al., "A c-arm fluoroscopy-guided progressive cut refinement strategy using a surgical robot." *J. Computer Aided Surgery*, 2000. 5(6): p. 373-390. PMID: 11295851,
28. Liao, R., J. Williams, L. Myers, S. Li, R.H. Taylor, C. Davatzikos, "Optimization of Multiple Isocenter Treatment Planning for Linac-Based Stereotactic Radiosurgery." *Computer Aided Surgery*, 2000, 5(4): p. 220-233.
29. Joskowicz, L. and R. Taylor, "Computers in Imaging and Guided Surgery." Computing in Science and Engineering, 2001. 3(5): p. 65-72.
30. K. Masamune, G.F., A. Patriciu, R. Susil, R. Taylor, L. Kavoussi, J. Anderson, I. Sakuma, T. Dohi, D. Stoianovici, "Guidance System for Robotically Assisted Percutaneous Procedures with Computed Tomography". *Computer Aided Surgery*, 2001, 6(6): p. 370-383.

31. G. Fichtinger, T. L DeWeese, A. Patriciu, A. Tanacs, D. Mazilu, J. H. Anderson, K. Masamune, R H. Taylor, and D. Stoianovici, "System For Robotically Assisted Prostate Biopsy And Therapy With Intra-Operative CT Guidance." *Journal of Academic Radiology*, 2002, 9(1): p. 60-74. PMID: 11918360.
32. Solomon S, Patriciu A, Masamune K, Whitcomb L, Taylor RH, Kavoussi L, Stoianovici D, "CT Guided Robotic Needle Biopsy: A Precise Sampling Method Minimizing Radiation Exposure", *Radiology*. 225 (2002): 277-282.
33. D. L. Rothbaum, J. Roy, P. Berkelman, G. Hager, D. Stoianovici, R. H. Taylor, L. L. Whitcomb, M. Howard Francis, and J. K. Niparko, "Robot-assisted stapedotomy: micropick fenestration of the stapes footplate," *Otolaryngology - Head and Neck Surgery*, 2002,127(5): p. 417-426.
34. R. Taylor, D. Stoianovici. "Medical Robotic Systems in Computer-Integrated Surgery". *Problems in General Surgery*, 2003, 20(2): p. 1-9.
35. R. Taylor, D. Stoianovici, "Medical Robotics in Computer-Integrated Surgery." *IEEE Transactions on Robotics and Automation*, 2003, 19(5), p. 765-781.
36. P. J. Berkelman, L. Whitcomb, R. Taylor, and P. Jensen, "A miniature microsurgical instrument tip force sensor for enhanced force feedback during robot-assisted manipulation." *IEEE Trans. Robotics and Automation*, 2003, 19(5), p. 917-922.
37. D. Rothbaum, J. Roy, G. Hager, R. Taylor, and L. Whitcomb, "Task Performance in stapedotomy: Comparison between surgeons of different experience levels," *Otolaryngology - Head and Neck Surgery*, 2003, 128(1): p. 71-77.
38. Yao, J. and R. H. Taylor, "Non-Rigid Registration and Correspondence in Medical Image Analysis Using Multiple-Layer Flexible Mesh Template Matching." *International Journal of Pattern Recognition and Artificial Intelligence (IJPRAI)*, 2003, 17(7): p. 1145-1165.
39. M. Armand, J. Lepistö, A. Merkle, K. Tallroth, X. Liu, R. Taylor, and J. Wenz, "Computer-Aided Orthopaedic Surgery with Near Real-Time Biomechanical Feedback," *APL Technical Digest*, vol. 25, pp. 242-252, 2004.
40. Cleary, K., V. Watson, D. Lindisch, D. Stoianovici, A. Patriciu, D. Mazilu, R. H. Taylor, G. Fichtinger, S. Xu, C. S. White, J. Donlon, and M. Taylor, "Precision placement of instruments for minimally invasive procedures using a "needle driver" robot." *International Journal of Medical Robotics and Computer Assisted Surgery,* 2005, 1(2): p. 1-9.
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50. United States Patent 9,549,781, I. Iordachita, M. Balicki, R. Taylor, and X. He, "Multi-function Force-sensing Surgical Instrument and Method of Use for Robotic Surgical Systems", Filed 5/30/2014, Issue date 1/24/2017.
51. United States Patent 9,554,864, R. H. Taylor, "Tool Exchange Interface and Control Algorithm for Cooperative Surgical Robots", Filed Aug. 2, 2011, Issue date Jan. 31, 2017.

52. United States Patent 9,554,865, K. Olds and R. Taylor, "Steady Hand Micromanipulation Robot", Filed 11/13/14, Issue date 1/31/17.
53. United States Patent 9,662,174, R. Taylor, M. Balicki, J. Handa, I. Iordachita, P. Gehlbach, I. Iordachita, and A. Uneri, "Micro-force Guided Cooperative Control for Surgical Manipulation of Delicate Tissue", Filed 7/22/2013, Issued 5/30/17.
54. Korean Patent 10-1759534, G. Hager, J. Handa, M. Balicki, P. Gehlbach, R. Kumar, and R. Taylor, "Visual Tracking and Annotation of Clinically Important Anatomical Landmarks for Surgical Interventions", PCT, Filed 11/1/10, Issue date 7/13/2017.
55. United States Patent 9,737,687 B2, M. Armand, M. Kutzer, C. Brown, R. H. Taylor, and E. Basafa, "Cable-Driven Morphable Manipulator", Utility, Issue date 22 August 2017.
56. United States Patent 9,770,828, M. Balicki, P. Kazanzides, R. Taylor, and X. Tian, "System for telerobotic surgery", Filed 9/28/12, Issue date 9/26/2017.
57. European Patent Office Patent 2595587, I. Iordachita, J. Kang, R. Taylor, and X. Liu, "Interferometric Force Sensor for Microsurgical Instruments", PCT, Filed 7/20/11, Issue date 11/8/17. (Also issued in Germany)
58. United States Patent 9,815,206 B2, M. Balicki, P. Kazanzides, A. Deguet, and R. Taylor, "Surgical system user interface using cooperatively-controlled robot", Utility, Filed Sep. 25, 2014, Issue date Nov. 14, 2017.
59. United States Patent 9,814,392, G. Hager, J. Handa, M. Balicki, P. Gehlbach, R. Kumar, and R. Taylor, "Visual Tracking and Annotation of Clinically Important Anatomical Landmarks for Surgical Interventions", PCT Filed 4/30/12, Issue date 11/14/17.
60. United States Patent 9,873,198 B2, G. Avrin, K. Olds, and R. Taylor, "Vibration Damping System", Filed Oct. 6, 2014, Issued Jan.23,2018.
61. Mexico Patent 353717, K. Olds and R. Taylor, "Steady Hand Micromanipulation Robot", Issued January 24, 2018.
62. Japan Patent 6290822, R. J. Webster, A. M. Okamura, N. J. Cowan, and R. H. Taylor, "Active Cannulas for Bio-sensing and Surgical Intervention", Filed Nov 15, 2006, Issued 2/16/2018.
63. Korea Patent 10-1837463, R. Taylor, M. Balicki, J. Handa, I. Iordachita, P. Gehlbach, I. Iordachita, and A. Uneri, "Micro-force Guided Cooperative Control for Surgical Manipulation of Delicate Tissue", Filed Issued March 6, 2018.
64. Korean Patent 10-1840312, R. H. Taylor, J. Handa, M. Balicki, I. Iordachita, A. Uneri, and P. Gehlbach, "Method for Presenting Force Sensor Information Using Cooperative Robot Control and Audio Feedback", Utility, Filed 8/2/10, Issued March 14, 2018.
65. Korean Patent 10-1841067, R. H. Taylor, I. I. Iordachita, J. U. Kang, and X. Liu, "Interferometric force sensor for microsurgical instruments", Utility, Filed 2010-07-20, Issued March 16, 2018.
66. Israel Patent 232310, K. Olds and R. Taylor, "Steady Hand Micromanipulation Robot", Issued 5/1/2018.
67. Japan Patent 6366506, K. Olds and R. Taylor, "Steady Hand Micromanipulation Robot", Issued 7/13/2018
68. United States Patent 10,039,530, R. H. Taylor, I. I. Iordachita, J. U. Kang, and X. Liu, "Interferometric force sensor for microsurgical instruments", Utility, Filed 2010-07-20, Issued 7 Aug 2018.
69. United States Patent 10,039,474 B2, M. Balicki and R. Taylor, "System for Tracking Microsurgical Instrumentation", Filed Jan. 28, 2014, Issued Aug. 7, 2018.
70. US Patent 10,045,882, M. A. Balicki, R. H. Taylor, J. U. Kang, P. L. Gehlbach, J. T. Handa, and J. Han, "Surgical Instrument and Systems with Integrated Optical Sensor", Application, Filed November 1, 2010, Issued 14 Aug 2018.
71. United States Patent 10,058,390, N. Simaan, R. H. Taylor, P. Flint, C. Chirikjian, and D. Stein, "Devices, Systems and Methods for Minimally Invasive Surgery of the Throat and Other Portions of Mammalian Body", Utility, Filed May 21, 2004, Issued 28 Aug 2018.
72. European Patent 2589406, N. Simaan, R. H. Taylor, P. Flint, C. Chirikjian, and D. Stein, "Devices, Systems and Methods for Minimally Invasive Surgery of the Throat and Other Portions of Mammalian Body", Utility, Filed May 21, 2004, Issued Oct. 10, 2018.
73. Korean Patent 10-1911843, R. H. Taylor, "Tool Exchange Interface and Control Algorithm for Cooperative Surgical Robots", Filed Aug. 2, 2011, Issued October 19, 2018.
74. European Patent 1973595, R. J. Webster, A. M. Okamura, N. J. Cowan, and R. H. Taylor, "Active Cannulas for Bio-sensing and Surgical Intervention", Filed Nov 15, 2006, Issued Oct. 31, 2018. (Also issued in France, United Kingdom, and Germany)

75. Korean Patent 10-1920731, J. Kang, P. Gehlbach, R. Taylor, and K. Zhang, "Surface Tracking and Motion Compensation Surgical Tool System", Issued Nov. 15, 2018.
76. United States Patent 10,166,080, M. A. Balicki, K. C. Olds, and R. H. Taylor, "Cooperatively-Controlled Surgical Robotic System with Redundant Force Sensing", Filed 2016-06-10, Issued Jan. 1, 2019.
77. United States Patent 10,188,552, X. He, I. Iordachita, Y. Horise, R. H. Taylor, and P. L. Gehlbach, "Surgical system providing hands-free control of a surgical tool", Filed Aug. 15, 2016, Issued Jan. 29, 2019.
78. United States Patent 10,188,281 B2, R. H. Taylor, S. D. Billings, P. L. Gehlbach, G. D. Hager, J. T. Handa, J. U. Kang, B. Vagvolgyi, R. Sznitman, and Z. Pezzementi, "Programmable multispectral illumination system for surgery and visualization of light-sensitive tissues ", Utility, Filed Aug 5, 2010, Issued Jan. 29, 2019.
79. United States Patent 10,226,304, I. Iordachita, H. Liu, M. Armand, R. H. Taylor, and A. Farvardin, "Shape tracking of a dexterous continuum manipulator", Filed Dec. 15, 2015, Issued March 12, 2019.
80. United States Patent 10,278,781 B2, R. H. Taylor, M. Balicki, and J. Handa, "Tool Exchange Interface and Control Algorithm for Cooperative Surgical Robots", Filed December 19, 2016, Issued May 7, 2017.
81. China Patent ZL201580050941.9, M. Balicki, P. Kazanzides, A. Deguet, and R. H. Taylor, "Surgical System User Interface Using Cooperatively-Controlled Robot", Filed Sept. 24, 2015, Issued July 2, 2019.
82. European Patent 2595586 (France, Germany, UK), J. Kang, P. Gehlbach, R. Taylor, and K. Zhang, "Surface Tracking and Motion Compensation Surgical Tool System", Filed July 20, 2011, Issued September 4, 2019.
83. United States Patent 10,363,164, X. He, I. Iordachita, R. H. Taylor, J. T. Handa, and P. L. Gehlbach, "Tool and tool system having independent axial and transverse force sensing", Filed Jun.8,2017, Issued July 30,2019.
84. United States Patent 10,369,045 B2, B. Gonenc, I. Iordachita, R. H. Taylor, C. Riviere, P. Gehlbach, and J. Handa, "Micromanipulation Systems and Methods", Filed July 27, 2015, Issued August 6, 2019.
85. United States Patent 10,368,720, K. C. Olds, T. S. Kim, R. H. Taylor, and A. Reiter, "System for stereo reconstruction from monoscopic endoscope images", Filed Nov.20,2014, Issued Aug. 6,2019.
86. United States Patent 10,406,026, N. Simaan, R. H. Taylor, and J. T. Handa, "System for Macro-micro Distal Dexterity Enhancement in Microsurgery of the eye", Filed 5/18/2009, Issued 9/10/2019.
87. United States Patent 10,426,554, J. Siewerdsen, Y. Otake, and R. H. Taylor, "System for On-Board Tracking and Surgical Navigation", Filed 4/30/2012, Issued 10/1/2019.
88. United States Patent 10,603,127, C. J. Hasser, R. H. Taylor, J. M. Leven, and M. A. Choti, "Laparoscopic Ultrasound Robotic Surgical System", Filed January 23, Issued March 31, 2020.
89. United States Patent 10,646,990, K. C. Olds and R. H. Taylor, "Delta Mechanism with Enhanced Torsional Stiffness", Filed Jul. 18, 2016, Issued May 12, 2020.
90. United States Patent 10,646,293 B2, C. J. Hasser, R. H. Taylor, J. M. Leven, and M. A. Choti, "Laparoscopic Ultrasound Robotic Surgical System", Filed January 23, Issued May 12, 2020.
91. United States Patent 10,781,419 R. H. Taylor, A. Canezin, M. Schrum, I. Iordachita, G. Chirikjian, M. Laskowski, S. Chakravarty, and S. L. Hoffman, "Mosquito Salivary Gland Extraction Device and Methods of Use", Utility, Filed June 13, 2017, Issued Sept. 22, 2020.
92. United States Patent 11,259,870 B2, S. P. DiMaio, C. J. Hasser, R. H. Taylor, D. Q. Larkin, P. Kazanzides, A. Deguet, B. P. Vagvolgyi, and J. Leven, "Interactive user interfaces for minimally invasive telesurgical systems", Utility, Filed Oct. 4 , 2017, Issued March 1, 2022.
93. United States Patent 11,503,819, R. H. Taylor, G. Chirikjian, I. Iordachita, H. Phalen, H. Wu, M. Xu, S. Lu, M. Pozin, J. S. Kim, C. Kocabalkanli, B. Vagvolgyi, J. Davis, T. Da, J. Chirikjian, S. Chakravarty, and S. Hoffman, "Apparatus and Method of Use for an Automated Mosquito Salivary Gland Extraction Device", Utility, Filed Aug. 17, 2020, Issued Nov. 22, 2022.
94. United States Patent 11,642,184, R. H. Taylor and Y. Sevimli, "Universal Surgical Tool Exchange and Identification System", Filed June 27, 2018, Issued May 9, 2023.
95. European Patent 2600788, R. H. Taylor, M. Balicki, and J. Handa, "Tool Exchange Interface and Control Algorithm for Cooperative Surgical Robots", Filed August 2, 2011, Issued July 26, 2023
96. United States Patent 11,717,365, Christopher J. Hasser, Russell H. Taylor, Joshua Leven, Michael Choti, “Laparoscopic ultrasound robotic surgical system”, Filed July 11, 2022, Issued August 8, 2023.
97. Canadian Patent 2,960,725, Marcin A. Balicki, Peter Kazanzides, Anton Deguet, Russell H. Taylor, "Surgical System User Interface Using Cooperatively-Controlled Robot", Filed September 24, 2015, Issued October 3, 2023.

Several other utility patents are currently in various stages of prosecution. Numerous preliminary patents are not included in this list.

Refereed Video Presentations

1. B. Vagvolgyi, M. Khrenov, P. Kazanzides, A. Deguet, J. Cope, S. Manzoor, R. H. Taylor, and A. Krieger, "Telerobotics for Remote Control of Medical Equipment in Contagious Environments": *EPSRC UK-RAS Medical Robotics for Contagious Diseases Challenge 2020*, Feb. 2021, (video presentation) https://youtu.be/WHTTIbRQWPk, "**Best Innovation" Award**.
2. B. P. Vagvolgyi, M. Khrenov, J. Cope, A. Deguet, P. Kazanzides, S. Manzoor, R. H. Taylor, and A. Krieger, "Telerobotic Operation of ICU Ventilators", (video presentation) *IEEE ICRA Workshop on the Impact of COVID-19 on Medical Robotics and Wearables Research*, May 17, 2021, https://youtu.be/1g1y5LfltYY.

SELECTED PRESENTATIONS (starting in 2001)

Conferences and Workshops (excluding paper presentations)

1. "Dependable Medical/Surgical Robots", **invited talk** to the *1st IARP/IEEE-RAS Joint Workshop on Technical Challenge for Dependable Robots in Human Environment*, Seoul Korea, May 22, 2001
2. "Computer-Integrated Surgery: Coupling Information to Action in 21st Century Medicine", **plenary address** to the *IEEE International Conference on Robotics and Automation*, Seoul Korea, May 23, 2001. . Text accompanying the speech is at http://www.icra2001.org/plenary_speech_1.pdf.
3. "Computer-Integrated Surgery: Coupling Information to Action in 21st Century Medicine", **invited address** to the *Annual Meeting of the Society of Urological Engineers*, Anaheim, Ca. June 2, 2001
4. Medical Robotics and Computer Integrated Surgery", **invited faculty lecture** to the Advanced Science Institute 2001: "New Frontiers of Intelligent Robotics" course, Tokyo, Japan, July 23-30,2001.
5. "The role of Medical Robotics in Computer-Integrated Surgery", **invited talk** to the German Workshop on Computer/Robot-assisted Surgery, July 19, 2001.
6. "Medical Robotics and Computer-Integrated Therapy Delivery: Coupling Information to Action in 21'st Century Surgery", **invited talk** to the *Ontario Consortium on Image-Guided Therapy and Surgery Annual Symposium*, October 18, 2001.
7. "What does the future hold for medical robotics?", **invited talk,** *Robot Industries Association Annual Meeting,* Orlando, November 8, 2001.
8. "Medical Robotics and Computer-Integrated Therapy Delivery: Coupling Information to Action in 21'st Century Surgery", **invited talk** to the *Special Symposium of the Japan Society for Promotion of Science*, December 6, 2001.
9. "Computer-Integrated Surgery: Where we are now and wither are we tending", **invited talk**, *CIMIT Symposium*, Boston, MA, February 12, 2002.
10. "Steady Hand Microsurgery/Deformable 2D-3D Registration", **invited talks** given back to back to the *Ontario Consorium for Image-Guided Therapy and Surgery*, Ontario, Canada, December 13, 2002.
11. "Steady Hand Microsurgery", **invited plenary talk** to the *NSF Annual Meeting of Engineering Research Centers*, November 3, 2002.
12. "Computer-Integrated Surgery: Coupling Information to Action in 21st Century Operating Rooms", **invited talk** at the *European Summer Institute on Medical Robotics*, Montpelier, France, September, 2003.
13. "Medical Robotics and Computer Integrated Surgery", **invited talk** to the *CSTAR/OCITS Joint Workshop*, Ontario, Canada, October 18, 2004.
14. "Advances in Robotics, CT, and Ultrasound Guided Surgery", **invited talk** to the *Orthopaedic Research Society Meeting*, Banff, Alberta, Canada, October 12, 2004.
15. "Future Research and Development: Robotic Surgical Systems Integration", **invited talk***, Integrated Research Team on Surgical Robotics*, Marina del Rey, CA, September 9, 2004. DoD/ TATRC.

16. "Biomedical Robotics and Biomechatronics: Scientific and Technical Foundations of a New Interdisciplinary Field for Research, Medical Application, and Industry", **invited talk**, *IEEE International Conference on Robotics and Automation workshop*, New Orleans, April 27, 2004.
17. "Robotics State-of-the-Art and Future Scenarios", **invited talk**, *OR of the Future*, Turf Valley, MD, March 18, 2004.
18. "Computer-Integrated Surgery: Coupling Information to Action in the 21st Century", **invited talk**, *International Symposium on Mechanical Systems Innovation*, Tokyo, Japan, March 7, 2004.
19. "Medical Robotics and Computer Integrated Surgery", **invited talk**, University of Maryland Medical Center, Department of Surgery Grand Rounds, Baltimore, MD, January 5, 2005.
20. "Computer-Integrated Surgical Systems", **invited talk**, NSF workshop *From Macro to Micro: Challenges and Opportunities in Integrative Complex Systems Engineering*, Washington, D.C., March 7, 2005.
21. "Computer-Integrated Surgery", **invited talk**, *ICRA*, Barcelona, Spain, April 19, 2005.
22. "Computer-Integrated Surgery: Coupling Information to Action in the 21st Century", **invited talk**, Operating *Rooms of the Future*, Washington, D.C., April 22, 2005.
23. "Computer-Integrated Surgery: Coupling Information to Action in the 21st Century", **invited plenary talk**, *44th Annual Conference of Japanese Society for Medical and Biological Society*, Tsukuba City, Japan, April 26, 2005.
24. "Computer-Integrated Surgery: Coupling Information to Action in the 21st Century", **invited plenary talk**, *First Asian Symposium on Computer Aided Surgery*, Tsukuba City, April 28, 2005.
25. "Computer-Integrated Surgery: Coupling Information to Action in the 21st Century", **speaker/organizer,** *I4M workshop*, School of Medicine, Baltimore, MD, February 27, 2006.
26. "Medical Robotics and Computer-Integrated Surgery", **keynote speaker**, *3rd COE workshop*, Tokyo, Japan, March 3-4, 2006.
27. **seminar speaker**, *Radiation Oncology*, Baltimore, MD, April 10, 2006.
28. "Medical Robotics and Computer-Integrated Surgery", **invited speaker**, *World Congress 2006*, Seoul, South Korea, August 27 – September 1, 2006.
29. "Medical Robotics and Computer-Integrated Surgery", **seminar speaker**, NIH, June 9, 2006.
30. "Medical Robotics and Computer-Integrated Surgery", **keynote speaker**, *Human Centered Robotic Systems*, Munich, Germany, October 6, 2006.
31. "Image Guidance for Surgical Robotics", **invited speaker**, *American College of Surgeos 92nd Annual Clinical Congress*, Chicago, IL, October 9, 2006.
32. "Medical Robotics and Computer-Integrated Surgery", **panel speaker**, *National Center for Image Guided Therapy,* Rockville, MD, October 19, 2006.
33. "Medical Robotics and Computer-Integrated Surgery", **invited speaker**, *TK60 Symposium*, Pittsburg, PA, March 9, 2007.
34. "Medical Robotics and Computer-Integrated Surgery", **keynote speaker**, *Design of Medical Devices Conference,* Minneapolis, MN, April 17, 2007.
35. "Medical Robotics and Computer-Integrated Surgery", **invited speaker**, *3rd Summer School in Surgical Robotics*, Montpellier, France, September 11, 2007.
36. "Robotics: The Future is Now", **invited speaker**, *Boston Chapter of the Johns Hopkins University Alumni Association*, Boston, MA, October 7, 2007.
37. "Medical Robotics and Computer-Integrated Surgery", *BioRob 2008*. Scottsdale, AZ. October 18, 2008. **Invited Speaker**
38. "Medical Robotics and Computer-Integrated Surgery", *Compsac 2008*. Turku, Finland. July 28, 2008. **Keynote Speaker**
39. "Perspectives on Medical Robotics and Computer-Integrated Interventional", *Medicine Medizin Innovativ 2008*. NurnbergMesse, Germany. July 10, 2008. **Invited Speaker**
40. "Ergonomics/Human Factors", *5th Annual Innovations in the Surgical Environment*. Baltimore, MD. June 27, 2008. **Panel Moderator**
41. "Future of Robotics", AAOS AICASKH. Providence, RI. May 15, 2008. **Invited Speaker**
42. "Surgical Assistance: Systems to Improve Efficiency and Outcomes", *Keck Institute Conference on New Frontiers in Medicine*. Claremont, CA. April 23, 2008. **Invited Speaker** and **Panelist**
43. "Medical Robotics and Computer-Integrated Interventions: where we are, wither we are tending, and how to get there", **Presidential Plenary Speaker,** *4th International Congress of the Minimally-Invasiv Robotic Association*, Quebec City, Quebec, Canada, January 29, 2009.

44. "Future trends and Opportunities in Medical Robotics Research", **Invited Panelist,** *4th International Congress of the Minimally-Invasive Robotic Association*, Quebec City, Quebec, Canada, January 31, 2009.
45. "Medical Robotics and Computer-Integrated Interventional Medicine", **Invited Speaker,** Seoul Digital Forum 2009, May 28, 2009.
46. "Medical Robotics and Computer-Integrated Interventional Medicine", **Invited Speaker,** Symposium on surgical computing, imaging, sensing, and robotics – from in silico patient modeling to clinical practice, Osaka University, Osaka, Japan, June 2, 2009.
47. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited speaker**, *4th Summer School in Surgical Robotics*, Montpellier, France, September 14, 2009.
48. "Medical Robotics and Computer-Integrated Interventional Medicine", **organizer & leadoff speaker,** *Tutorial on Medical Robotics* held as part of *MICCAI 2009*, September 20, 2009.
49. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited speaker**, *3rd NIH and NCIGT Image-Guided Therapy Workshop,* Arlington, Va., March 9, 2010.
50. "Medical Robotics and Computer-Assisted Interventional Systems: Integrating Imaging, Intervention, and Informatics to Improve Patient Care", **invited speaker**, *Biomedical Engineering as Enabler for Research, Diagnosis and Therapy: GSISH Second Invited Symposium*, Spritzingse, Bavarian Alps, March 21, 2010.
51. "A Microsurgical Assistant for Retinal Surgery", **invited speaker**, *Stanford Medical Innovation Conference, Stanford University*, Stanford California, April 10, 2010.
52. "A Perspective on Flexible Robots for MIS", **invited speaker**, in *ICRA Workshop on Continuum and Serpentine Robots for Minimally Invasive Surgery*, Anchorage, Alaska May 3 2010.
53. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited speaker**, *ICRA Workshop on Medical Cyber-Physical Systems*, Anchorage, Alaska, May 7, 2010.
54. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited plenary speaker**, *American Control Conference*, Baltimore, Maryland, June 30, 2010.
55. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited speaker**, *North American School on Medical Robotics*, Seattle, Washington, August 24, 2010.
56. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited speaker**, *Advances in Surgical Technology*, Orlando, Florida, November 4, 2010.
57. "JHU Center for Computer-Integrated Surgical Systems and Technology (CISST ERC) - Sustainability Post-Graduation", **invited speaker**, *ERC Association Annual Meeting*, Bethesda, Maryland, December 2, 2010.
58. Medical Robots: Extending Human Capabilities in an Especially Challenging Environment, **invited speaker**, *ICRA 2011 workshop on Mechanisms for Surgical Robotics*, Shanghai, China, May 9, 2011.
59. "Medical Robotics and Computer-Integrated Interventional Medicine", **keynote speaker**, *IASTED International Conference on Imaging and Signal Processing in Healthcare and Technology*, Washington, DC, May 17, 2011.
60. "Medical Robotics and Computer-Integrated Interventional Systems", *Computer-Assisted Orthopaedic Surgery (CAOS) Workshop on Novel Technologies*, London, England, June 15, 2011.
61. "A Robotic Assistant for Trans-Oral Surgery: The Robotic Endo-Laryngeal Flexible (Robo-ELF) Scope", *Hamlyn Symposium on Medical Robotics*, London, England, June 19, 2011.
62. "Recent Work Toward a Microsurgical Assistant for Retinal Surgery", **invited lecture,** *Hamlyn Symposium on Medical Robotics*, London, England, June 20, 2011.
63. "A Multi-view Active Contour Method for Bone Cement Reconstruction from C-Arm X-Ray Images", *Information Processing in Computer-Assisted Interventions (IPCAI)",* Berlin, Germany, June 22, 2011.
64. "Academic, Clinical, and Industry Partnerships", *IPCAI-ISCAS Joint Panel Session*, Berlin, Germany, June 23, 2011.
65. "Medical Robotics and Computer-Integrated Interventional Medicine", *5th Summer School Surgical Robotics,* Montpelier, France, Sept. 12, 2011.
66. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited keynote,** *SPIE Medical Imaging: Image-Guided Procedures, Robotic Interventions and Modeling*, San Diego, February 5, 2012
67. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited lecture,** *Symposium on Robotics Science and Technology*, College de France, Paris, June 12, 2012.
68. "Medical Robotics and Computer-Interventional Medicine", "A Microsurgical Assistant for Retinal Surgery", "Statistical Atlases", and other topics. Lectures given at the *EMBS Summer School on Biomedical Imaging,* Berners Island, Brittany, June 24-25, 2012.

69. "Engineering Research Center for Computer-Integrated Surgical Systems and Technology", *Laboratory for Computational Sensing and Robotics Industry Day Symposium,* July 16, 2012.
70. "Medical Robotics and Computer Integrated Interventional Medicine", *3rd North American Summer School on Medical Robotics,* London Ontario, August 13, 2012.
71. "Medical Robotics and Computer-Integrated Interventional Medicine", **keynote lecture,** *Daegu Global Innovation Festival*, Daegu, Korea, December 6, 2012.
72. "Medical Robotics and Computer-Integrated Interventional Medicine", *NCIGT Workshop*, **invited speaker**, Crystal City, March 21, 2013.
73. "3D Ultrasound-Guided Retrieval of Foreign Bodies from a Beating Heart using a Dexterous Surgical Robot", *Hamlyn Symposium on Medical Robotics,* London, June 24, 2013.
74. "Toward a sub-millimetric triaxial force sensing instrument with integrated fiber Bragg grating for vitreoretinal surgery", *Computer Assisted Radiology and Surgery Conference,* Heidelberg, June 27, 2013.
75. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited speaker**, *5th Summer School Surgical Robotics,* Montpelier, France, Sept. 7, 2013.
76. "A Microsurgery Assistant System", **invited speaker,** Mathematical Challenges in *Ophthalmology Conference*, UCLA, Los Angeles, California, January 17, 2014.
77. "The Future of Medical Robotics and Computer-Assisted Interventional Systems", **invited speaker and panelist**, *MedTech Partners Conference*, Erlangen, Germany, February 19, 2014.
78. "3D Ultrasound-Guided Retrieval of Foreign Bodies from a Beating Heart using a Dexterous Surgical Robot", *IEEE International Conference on Robotics and Automation",* Hong Kong, June 4, 2014.
79. "Medical Robotics and Computer-Integrated Interventional Systems: where we are and wither we are tending", **Invited Talk** to the *Asian Conference on Computer Aided Surgery (ACCAS)*, Fukuota, Japan, June 25, 2014.
80. "The human and the machine: Robotic Cooperative Systems in MIS", **invited talk** at the *BEST Innovation Symposium*, IRCAD Institute, Strasbourg, France, July 10, 2014.
81. "An Open-Source Software Environment for the da Vinci Research Kit and Other Medical Robotics Research", *Hamlyn Symposium Workshop*, London, July 15, 2014.
82. "Medical robotics and computer-integrated interventional medicine" **invited talk** at the *4th Biennial North American Summer School on Surgical Robotics*, Carnegie Mellon University, Pittsburgh, July 21, 2014.
83. "An Open-Source Software Environment for the da Vinci Research Kit and Other Medical Robotics Research", *4th Biennial North American Summer School on Surgical Robotics*, Carnegie Mellon University, Pittsburgh, July 22, 2014.
84. "The Future of Medical Robotics and Computer-Assisted Interventional Systems", **invited talk** at the *Johns Hopkins Symposium on Head and Neck Robotic Surgery, Adjuvant Therapy and Emerging Technologies*, Baltimore, July 25, 2014.
85. "Common Components for Medical Robotics and Computer-Integrated Surgery Research", short talk at the *IROS2014 "Medical Robotics" Workshop: Community Consensus Benchmarks for Clinical Translation of Medical Robots*, Chicago, September 18, 2014.
86. "Will Robotics Save Medicine", **invited talk,** *Techna 2014 Symposium – Robotics for Healthcare*, Toronto, October 31, 2014.
87. "Medical Robotics and Computer-Integrated Interventional Systems", **invited talk** at the *North American Spine Society Annual Meeting*, San Francisco, November 13, 2014.
88. "Medical Robotics and Computer-Integrated Interventional Systems", **invited talk** at *Surgetica 2014*, Chambery, France, December 3, 2014.
89. "The Case for Shared Research Frameworks", *ICRA Workshop on Shared Frameworks for Medical Robotics Research*, Seattle, Washington, May 30, 2015.
90. "The role of medical robotics in the next 25 years", Short panel talk at the *Hamlyn Symposium on Medical Robotics"*, June 22, 2015.
91. "Robotically Assisted Surgical Devices (RASD): Key Non-Clinical Performance Characteristics", **Invited Talk and Panel Participation,** *US Food and Drug Administration Workshop on Robotically-Assisted Surgical Devices (RASD)*, Silver Spring, Maryland, July 27-28, 2015.
92. "Medical Robotics and Computer-Integrated Interventional Systems", **invited talk** at the *7th European Summer School on Surgical Robotics*, Montpelier, France, September 5, 2015.
93. "The Role of Imaging in Computer-Integrated Interventional Systems", **invited talk** at the *MICCAI Workshop Interventional Microscopy"*, Munich, Germany, October 5, 2015.

94. "Medical Robotics in Image-Guided Interventions", **invited talk** at the *MICCAI Workshop on Advanced Robotics Assistance in Medicine: IROS meets MICCAI"*, Munich, Germany, October 5, 2015.
95. **"**Medical Robotics and Computer-Integrated Interventional Medicine", **Invited Talk**, *2015 DGIST Global Innovation Festival*, Daegu, South Korea, November 19, 2015.
96. **"**Medical Robotics and Computer-Integrated Interventional Medicine", **Plenary Lecture**, *Japanese Society of Computer Aided Surgery*, November 21, 2015.
97. "Medical Robotics and Computer-Integrated Interventional Medicine", **Plenary Lecture,** *2016 Fitzpatrick Institute for Photonics (FIP) Symposium on Photonics Science and Technology,* Durham, NC, March 14, 2016.
98. "Image-guidance methods in robot-assisted interventions", **Invited Talk,** *Hamlyn Workshop on Surgical Imaging, Guidance, and Augmented Reality"*, London, England, June 28, 2016.
99. "Collaboration with Engineering: Projects and Pathways", **Invited Talk,** *Surgery Innovation Symposium*, Baltimore, Maryland, September 14, 2016.
100. **"**Medical Robotics and Computer-Integrated Interventional Medicine", **Invited Lecture**, *Computer Assisted Medical Interventions (CAMI) Annual Meeting*, Rennes, France, Dec. 13, 2016.
101. "Medical Robotics" – **panelist, co-organizer, and discussion leader**, *AAAS Halcyon Dialogs on Robotics*, Washington, DC, January 30-31, 2017.
102. "Medical Automation, Big Data, and Robotics" – **invited panelist**, Medical Automation & Robotics Roundtable, University of Maryland Carey School of Law, Baltimore, MD, April 7, 2017.
103. "A 30 Year Perspective on Medical Robotics" – **invited talk**, *Hamlyn Symposium on Medical Robotics*, London, June 27, 2017.
104. "A 30 Year Perspective on Medical Robotics" – **invited plenary talk**, *Huashan International Neurosurgical Conference*, Shanghai, November 17, 2017.
105. "A 30 Year Perspective on Medical Robotics" – **invited plenary talk**, *International Symposium on Medical Robotics (ISMB)*, Atlanta, March 2, 2018.
106. "Current and Future Directions of Information Processing in Computer-Assisted Intervention", **panelist**, *IPCAI 2018*, June 21, 2018.
107. "A 30 Year Perspective on Medical Robotics" – **Distinguished Lecture,** *Institution of Mechanical Engineers*, London, June 26, 2018.
108. "A 30 Year Perspective on Medical Robotics and Introduction to LCSR" – **Keynote Speech,** *International Medical Robot Frontier Technology Summit*, Beijing, October 28, 2018.
109. "A 30 Year Perspective on Medical Robotics" – **Keynote Speech,** *World Life Science Conference*, Beijing, October 28, 2018.
110. "Medical Robotics and Computer-Integrated Surgery", **Keynote Speech,** *World Medical Robotics Conference*, Munich, November 10, 2018.
111. "A 30 Year Perspective on Medical Robotics" – **Keynote Speech,** *Signate Smart Robotic and Artificial Intelligence Workshop*, Hong Kong, December 10, 2018.
112. "A 30 Year Perspective on Medical Robotics" – **invited lecture,** *Spring School on Medical Robotics,* Atlanta, Georgia, April 2, 2019.
113. "Complementary Situational Awareness", **workshop talk** at *International Symposium on Medical Robotics*, Atlanta, Georgia, April 3, 2019.
114. "Autonomy and Semi-Autonomous Behavior in Surgical Robot Systems", *ICRA Workshop on Open Challenges and State-of-the-Art in Control System Design and Technology Development for Surgical Robotic Systems*, Montreal, Canada, May 24, 2019.
115. "Medical Robotics and Computer-Integrated Interventional Systems", **invited talk** at the *Summer School on Medical Robotics"*, Montpelier, France, September 28, 2019.
116. "A 30 Year Perspective on Medical Robotics", **invited talk** at the *US-Japan MedTech Frontiers* Symposium, Tokyo, Japan, November 6, 2019.
117. "A 30 Year Perspective on Medical Robotics", **invited talk** and workshop session for students at Kobe University, in conjunction with the *6th Annual Medtech & Healthtech Innovation Forum,* Kobe, Japan, November 7, 2019.
118. "A 30 Year Perspective on Medical Robotics", **invited talk** at the *6th Annual Medtech & Healthtech Innovation Forum,* Kobe, Japan, November 8, 2019.
119. "Surgical Robots Interacting with Anatomy", **invited narrated PowerPoint talk** at the *Intelligent Robot Interactions with the Anatomy* workshop at the *IEEE IROS Conference*, Macao, Nov. 8, 2019.

120. "Autonomy in Medical Robots", **panel presentation**, *Tokyo Forum 2019: Digital Revolution*, Tokyo, December 7, 2019.
121. "Autonomy and Semi-Autonomous Behavior in Surgical Robot Systems", *IAA Assured Autonomy Workshop",* JHU Applied Physics Lab, April 29, 2019.
122. "Intelligent robots in surgery and infectious disease crises", *National Academies-organized workshop "Adapting to Shorter Time Cycles: A Workshop Series for the United States Air Force",* **invited talk**, October 1, 2020.
123. "Medical Robotics: Challenges and Opportunities", *ErgoX: Challenges and Priorities for Human-Centered Robotics*, **invited talk**, October 14, 2020.
124. "Challenges and Priorities for Medical Robotics: Closing the gap between research and deployment", **invited talk and panel**, *2020 BIOMEDigital Conference*, November 4, 2020.
125. "Medical Robotics and Computer-Assisted Surgery: A three-way partnership between physicians, technology, and information to improve patient care", **Keynote Address**, *Surgeons and Engineers: A Dialogue on Surgical Simulation*, virtual meeting organized by the American College of Surgeons, March 10, 2021.
126. "Autonomy and Intelligent Control for High Dexterity Medical Robots", **invited talk,** *ICRA Workshop on Holistic Integration of Design, Sensing, and Intelligence in Dexterous Surgical Robotic Systems*, June 4, 2021.
127. "A Thirty-Year Perspective on Medical Robotics", *International Workshop on New Trends in Medical and Service Robots (MESROB 2021)*, **plenary talk**, June 9, 2021.
128. "A Thirty Year Perspective on Medical Robotics and Computer-Integrated Interventional Medicine", **Closing Keynote Address,** *Medical Imaging and Augmented Reality (MIAR)*, videoconference presentation to conference in Shanghai, July 16, 2022.
129. "Autonomy and Semi-Autonomous Behavior in Surgical Robot Systems", **Keynote talk** (via videoconference), *MICCAI 2022 Workshop on Imaging Systems and GI Endoscopy*, Singapore, September 18, 2022
130. "Human-Machine Collaboration in Surgical Applications", **Invited talk**, *Healthcare Innovation and Technology Summit*, Hong Kong, October 14, 2022.
131. "Human-Machine Partnerships in Computer-Integrated Interventional Medicine", **invited lecture,** *11th Summer School on Surgical Robotics*, LIRRM, Montpelier, France, September 4, 2023 (remote presentation).
132. "Fireside Chat" on the future of surgical robotics, **invited talk**, *International Conference on Medical Image Computing and Computer-Assisted Interventions (MICCAI)"*, Vancouver, October 9, 2023.
133. "Clinical Translation – Computer Assisted Intervention", **invited panelist,** *International Conference on Medical Image Computing and Computer-Assisted Interventions (MICCAI)"*, Vancouver, October 11, 2023.

Invited University Colloquia, Grand Rounds Presentations, and Seminars

1. "Medical Robotics and Computer Integrated Surgery", Carnegie Mellon University, April 2001.
2. "Medical Robotics: The Key for Computer-Integrated Therapy Delivery", Boston University, April 2002.
3. "Computer-Integrated Surgery: Where We Are Now and Wither We Are Tending", Drexel University, February, 2002.
4. "Steady Hand Microsurgery/Deformable 2D-3D Registration", MERITS Seminar, Carnegie Mellon University, November 25, 2002.
5. "Computer-Integrated Surgery: Coupling Information to Action in 21st Century Operating Rooms", Yale University, March, 2004.
6. "Medical Robotics and Computer-Integrated Surgery", Columbia University, December, 2004.
7. "Medical Robotics and Computer-Integrated Surgery", University of Maryland Medical Center Grand Rounds, January 5, 2005.
8. "Medical Robotics and Computer-Integrated Surgery", University of Calgary, Calgary, Canada, October 30, 2006.

9. "Medical Robotics and Computer-Integrated Surgery", George Washington University, Washington D.C., March 24, 2006.
10. "Computer-Integrated Surgery", *Emerging Technology and Best Industry Practices Seminar*, Boston University, March 31, 2006.
11. "Medical Robotics and Computer-Integrated Surgery", McMaster School of Biomedical Engineering, McMaster University,
12. "Medical Robotics and Computer-Integrated Surgery", Surgical Grand Rounds Hospital for Sick Children, Toronto, Canada, February 9, 2007.
13. "Medical Robotics and Computer-Integrated Surgery", NIH STEPS Symposium, May 10, 2007.
14. "Medical Robotics and Computer-Integrated Surgery", USC/Intuitive, California, June 19, 2007.
15. "Medical Robotics and Computer-Integrated Surgery", Fraunhofer Institute, Munich, Germany, July 16, 2007.
16. "Medical Robotics and Computer-Integrated Surgery", UCLA. January 15, 2008.
17. "Medical Robotics and Computer-Integrated Surgery". Queen's University. March 13, 2008.
18. "Medical Robotics and Computer-Integrated Surgery". UNC/Duke/NCSU. April 07, 2008.
19. "Computer-Integrated Interventional Medicine – The vision of the CISST ERC", *JHU Winter School on Medical Robotics and Computer-Integrated Interventional Systems*, Jan 12, 2009.
20. "Medical Robotics and Computer-Integrated Interventional Medicine", Michigan State University. Jan 22, 2009.
21. "Medical Robotics and Computer-Integrated Interventional Medicine", *Cross-faculty Symposium on Medical Robotics and Computer-Assisted Interventions,* Imperial College, London, May 19, 2009.
22. "Medical Robotics and Computer-Integrated Interventional Medicine", Yonsei University, Seoul, Korea. May 29, 2009.
23. "Medical Robotics and Computer-Integrated Interventional Medicine", Shiga University, Shiga, Japan. June 1, 2009.
24. "Medical Robotics and Computer-Integrated Interventional Medicine", University of Tokyo, Tokyo, Japan. June 3, 2009.
25. "Statistics and Prior Models in Image-based Modeling and Interventions", Johns Hopkins Medical Imaging Symposium, November 11, 2009.
26. "A Microsurgical Assistant for Retinal Surgery", talk to technical staff at Intuitive Surgical, Inc., Sunnyvale, California, November 23, 2009.
27. "Medical Robotics and Computer-Assisted Interventional Systems: Integrating Imaging, Intervention, and Informatics to Improve Patient Care", Surgical Grand Rounds, Mt. St. Agnes Hospital, February 12, 2010.
28. "A Microsurgical Assistant for Retinal Surgery", Mechanical Engineering Department Seminar, The University of Maryland, May 14, 2010.
29. "Medical Robotics and Computer-Integrated Interventional Medicine", Robotics Institute Seminar, Carnegie-Mellon University, January 21, 2011.
30. "Medical Robotics and Computer-Integrated Interventional Medicine", Computer Science Department Seminar, University of Maryland, January 31, 2011.
31. "Medical Robotics and Computer-Integrated Interventional Medicine",APL Colloquium Series, Johns Hopkins Applied Physics Lab, January 13, 2011.
32. "Medical Robotics and Computer-Integrated Interventional Medicine", Biomedical Imaging Research Centre, University of Western Ontario, January 18, 2012.
33. "Medical Robotics and Computer-Integrated Interventional Medicine", Johns Hopkins Applied Physics Laboratory, Jan 13, 2012.
34. "A Microsurgical Assistant for Retinal Surgery", Computer-Assisted Medical Interventions, Canadian Surgical Technologies and Advanced Robotics (CSTAR) Centre, University of Western Ontario, January 20, 2012.
35. "A Microsurgical Assistant for Retinal Surgery", GRASP Lab Seminar, University of Pennsylvania, Philadelphia, April 20, 2012.
36. "Medical Robotics and Computer-Integrated Interventional Medicine", Siemens Corporate Research Laboratory, July 26, 2012.
37. "Medical Robotics and Computer-Integrated Interventional Medicine", Robotics and Mechatronics Center, Forschungszentrum der Bundesrepublik Deutschland für Luft- und Raumfahrt. (DLR), Munich, July 30, 2012.

38. "Medical Robotics and Computer-Integrated Interventional Medicine", Computer Science Department, Montana State University, Bozeman, Montana, October 26, 2012.
39. "A Microsurgery Assistant for Retinal Surgery", Robotics Engineering Department, Daegu Gyeongbuk Institute of Science and Technology (DGIST), December 7, 2012.
40. "Medical Robotics and Computer-Integrated Interventional Medicine", **distinguished lecture**, Stanford EE Computer Science Systems Colloquium, Stanford University, January 16, 2013.
41. "Medical Robotics and Computer-Integrated Interventional Medicine", Computer Science Colloquium at the University of Texas, Arlington, March 8, 2013.
42. Medical Robotics and Computer-Integrated Interventional Medicine", National Robotics Engineering Center, Carnegie-Mellon University, Pittsburgh, March 6, 2013.
43. "Medical Robotics and Computer-Integrated Interventional Medicine", Computer Science Colloquium at the University of Texas, Arlington, March 8, 2013.
44. "Medical Robotics and Computer-Integrated Interventional Medicine", Mechanical Engineering Colloquium at Vanderbilt University, October 7, 2013
45. "Medical Robotics and Computer-Integrated Interventional Medicine", Invited Grand Rounds talk to Department of Surgery at Brigham and Women's Hospital, September 24, 2014.
46. "Medical Robotics and Computer-Integrated Interventional Medicine", MIT Robotics Seminar Series, MIT, February 7, 2015.
47. "Medical Robotics and Computer-Integrated Interventional Medicine", Hamlyn **Distinguished Lecture** Series, Imperial College, London, April 24, 2015.
48. "Medical Robotics and Computer-Integrated Interventional Medicine", Robotics and Mechatronics Center, Forschungszentrum der Bundesrepublik Deutschland für Luft- und Raumfahrt. (DLR), Munich, October 8, 2015.
49. "Medical Robotics and Computer-Integrated Interventional Medicine", **distinguished colloquium**, Rutgers University, February 19, 2016.
50. "Medical Robotics and Computer-Integrated Interventional Medicine", Korean Institution of Science and Technology (KIST), Sept. 27, 2016.
51. "Medical Robotics Research" – **Invited Talk & Panel Discussion**, Robotics Engineering Department, Daegu Gyeongbuk Institute of Science and Technology**,** Daegu, Korea, January 10, 2017.
52. "Medical Robotics and Computer-Integrated Surgery" – **invited talk**, SRI International, Menlo Park, California, February 14, 2017.
53. "Medical Robotics and Computer-Integrated Surgery" – **Invited talk**, Mechanical and Automation Engineering, Chinese University of Hong Kong, June 5, 2017.
54. "A 30 Year Perspective on Medical Robotics" – **invited talk**, University of California at Berkeley, February 26, 2018.
55. "A 30 Year Perspective on Medical Robotics" – **invited talk**, University of Tokyo, December 9, 2019.
56. "A 30 Year Perspective on Medical Robotics" – **invited talk,** Shanghai Jiaotong University Robotics Institute, Shanghai, China, October 18, 2019.
57. "Human-robot partnerships in interventional medicine and infectious disease crises", **invited colloquium,** UC Berkeley, November 9, 2020.
58. "Human-robot partnerships in interventional medicine and infectious disease crises", **invited seminar,** University of Toronto Robotics Institute, January 11, 2021.
59. "Human-robot partnerships in interventional medicine and infectious disease crises", **invited zoom seminar,** , Daegu Gyeongbuk Institute of Science and Technology (DGIST), March 22, 2021.
60. "A 30 Year Perspective on Medical Robotics", **invited seminar**, Cutting Edge Technology to Clinical Practice Series, Sidney Kimmel Cancer Center, Johns Hopkins School of Medicine, June 24, 2021.
61. "A 30 Year Perspective on Medical Robotics", **invited seminar**, JHU Applied Physics Lab Intelligent Systems Center, July 1, 2021
62. "A Thirty-Year Perspective on Medical Robotics and Computer-Integrated Interventional Medicine: Yesterday, Today, and Tomorrow", **invited talk**, National Academy of Engineering Section 12 Seminar Series, December 15, 2021.
63. "Autonomy and Semi-Autonomous Behavior in Surgical Robot Systems". **Invited talk,** IMAG/MSM Working Group on Multiscale Modeling and Viral Pandemics, Dec. 16, 2021.
64. "A Thirty Year Perspective on Medical Robotics and Computer-Integrated Interventional Medicine", **Invited Online Seminar,** Biomedical Engineering, ShanghaiTech University, April 28, 2022.

65. “Image-based Automation in Robotic Surgery”, **Invited *talk,*** *Thought Leadership Series on Surgical Robotics,* Multi-modal Medical Robotics Centre, Hong Kong, October 13, 2022.
66. “A Thirty Year Perspective on Medical Robotics, **Invited Seminar**, The Chinese University of Hong Kong, October 18, 2022.
67. “Robot Assisted ENT Surgery”, **invited seminar,** University of British Columbia, September 13, 2023.

Other

1. "Computer-Integrated Surgery", talk to upper management, G.E. Medical Systems, Milwaukee, April 5, 11’th 2001.
2. "Medical Robotics and Computer-Integrated Therapy Delivery: Coupling Information to Action in 21st Century Surgery", **invited talk** to the University Health Consortium, Atlanta, Sept. 11, 2001.
3. "Medical Robotics and Computer-Integrated Therapy Delivery: Coupling Information to Action in 21st Century Surgery", **invited talk** to the Houston Surgical Society, Houston, September 24, 2001.
4. "Computer-Integrated Surgery", talk at IBM T. J. Watson Research Center, October 29, 2001.
5. "Computer-Integrated Surgery: Coupling Information to Action in the 21st Century", **invited talk**, Philips Research, Briarcliff, NY, May 16, 2005.
6. "Computer-Integrated Surgery", *CMU Surgery for Engineers*, Pittsburgh, PA, May 3, 2006.
7. "Medical Robotics and Computer-Integrated Surgery", *Society of Engineering Alumni, Johns Hopkins University,* Los Angeles, CA, November 5, 2006.
8. "Medical Robotics and Computer-Integrated Surgery", *Fraunhofer Workshop*, Munich Germany, November 14, 2006.
9. "Robotics: The Future is Now", NY Chapter of the Johns Hopkins Alumni. February 10, 2008.
10. "NSF Engineering Research Center for Computer-Integrated Surgical Systems and Technology", presentation to members of US Congressional Staff, February 20, 2009.
11. "Medical Robotics and CIIM", Presentation to Siemens Management, Erlangen, Germany, March 24, 2009.
12. "Registration and Visualization for Laparoscopic Surgery", Fraunhofer/JHU workshop, Munich, Germany, March 25, 2009.
13. "Information-Enhanced Interventional Medicine", Fraunhofer/JHU workshop, Munich, Germany, March 25, 2009.
14. "A Microsurgery Assistant System for Retinal Surgery", Presentation to Zeiss technical staff, Oberkochen, Germany, March 26, 2009.
15. "E-science meets radiation oncology: Using statistical shape analysis to improve the quality and efficiency of radiation therapy planning", presentation for Paul Maritz, Johns Hopkins University, April 7, 2009.
16. "Steady-hand robot and workstation for microsurgery", Poster presentation and demonstration for NSF CPS exhibition to US Senate and Congressional staffs, July 9, 2009.
17. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to management from Hologic Corp., JHU, July 27, 2009.
18. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visiting delegation from NASA, JHU, September 17, 2009.
19. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visiting delegation from Twente University, JHU, November 11, 2009.
20. "Introduction to the CISST ERC and to our Microsurgical Assistant Project", presentation to visitors from Alcon, Inc., November 19, 2009.
21. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visiting delegation from New Zealand Embassy, JHU, December 14, 2009.
22. A Microsurgical Assistant for Retinal Surgery", presentation to representatives of Auris Inc, May 13, 2010.
23. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to Executives from Siemens AX, JHU, Baltimore, July 16, 2010.
24. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visitors from Johnson and Johnson, JHU, Baltimore, July 22, 2010.
25. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visitors from the Danish "RoboCluster" robotics research consortium, JHU, Baltimore, October 28, 2010.

26. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visitors from Hansen Medical, JHU, Baltimore, November 22, 2010.
27. "Overview of Medical Robotics and Computer-Integrated Intervention Research at CISST ERC", presentation to visiting US Congressional and Senate Staff members, Johns Hopkins University, June 2, 2011.
28. "The CISST ERC", *Johns Hopkins Applied Physics Laboratory Collaboration Expo*, Johns Hopkins APL Kossiakoff Center, June 9, 2011.
29. "Medical Robotics and Computer-Integrated Interventional Systems" to students in the *JHU Meyerhoff Bridge Program*, Johns Hopkins University, June 28, 2011.
30. "Medical Robotics and Computer-Assisted Microsurgery" to visitors from Cochlear Corporation, July 19, 2011.
31. "A Microsurgery Assistant for Vitreoretinal Surgery", Carl Zeiss Meditec, Oberkochen, Germany, July 30, 2012.
32. "Overview of the Laboratory for Computational Sensing and Robotics", LCSR Industry Day, Johns Hopkins University, October 18, 2013.
33. "Medical Robotics Research at JHU", LCSR Industry Day, Johns Hopkins University, October 18, 2013.
34. "Medical Robotics and Computer-Integrated Interventional Medicine", invited talk at Siemens AX, Forscheim, Germany, February 18, 2014.
35. "Medical Robotics and Computer-Integrated Interventional Medicine", invited talk at Kuka Robotics, Augsburg, Germany, February 20, 2014.
36. "The Future of Medical Robotics and Computer-Assisted Interventional Systems", Presentation to John Dineen (CEO of GE Health Care) at Johns Hopkins University, March 12, 2014.
37. "The Laboratory for Computational Sensing and Robotics", short overview for MSE Visitors Day.
38. "The Laboratory for Computational Sensing and Robotics and the CISST ERC", Presentation to Dr. Lynn Preston, Emeritus Director of the NSF Engineering Research Centers Program, May 9, 2014.
39. "Medical Robotics and Computer-Assisted Interventional Systems", Presentation to Dr. Michael Zinner (Chairman of Surgery, Brigham and Women's Hospital), Johns Hopkins University, May 22, 2014.
40. "Medical Robotics and Computer-Integrated Interventional Systems", **invited talk** at Daegu Gyeonbuk Institute of Science and Technology (DGIST), Daegu, Korea, June 23, 2014.
41. "Medical Robotics and Computer-Assisted Interventional Systems", presentation to John Dineen and other GE Health Care executives, July 8, 2014.
42. "Overview of the Laboratory for Computational Sensing and Robotics", LCSR Industry Day, Johns Hopkins University, September 8, 2014.
43. "Overview of Medical Robotics Research in LCSR", LCSR Industry Day, Johns Hopkins University, September 8, 2014.
44. "Medical Robotics and Computer-Integrated Interventional Medicine", **invited talk** at Siemens Corporate Research, Princeton, November 7, 2014.
45. "Ph.D. Coop and Internship Programs: An effective means for WSE-Industry collaboration", presentation to General Electric Healthcare Senior Management, San Ramon, California, May 26, 2015.
46. "Medical Robotics and Computer-Integrated Interventional Medicine: Integrating Imaging, Intervention, and Informatics to Improve Patient Care", **Commemorative Award Acceptance Speech**, *2015 Honda Prize Presentation Event,* Tokyo, Japan, November 17, 2015.
47. "Engineering Innovations for Interventional Medicine", *Symposium on Engineering in Healthcare*, Johns Hopkins University, November 21, 2016.
48. "Medical Robotics", **sort talk and invited panel member**, Ambassador Leaders Program (for high school students), Johns Hopkins University, August 1, 2017.
49. "A 30 Year Perspective on Medical Robotics" – **invited talk**, Intuitive Surgical, Inc., Sunnyvale, California, September 29, 2017.
50. "A 30 Year Perspective on Medical Robotics" – **invited talk**, Philips Research North America, Cambridge, Mass., August 13, 2018.
51. "Surgical and Vision-Guided Robotics", **podcast (**R. H. Taylor and M. Safran), in *All Things Photonics*. Photonics Media, 2021, https://www.photonics.com/Podcast/Surgical_and_Vision-Guided_Robotics_with_Moshe/pce39
52. "The role of AI in Robotic Surgery", **podcast** interview with Anirban Mukhopadhyay in *AI-ready Healthcare*, recorded February 23, 2022, posted live April 5, 2022. https://anchor.fm/anirban-mukhopadhyay7/episodes/Russ-Taylor-The-role-of-AI-in-Robotic-Surgery-e1ggj8r

53. "Introductory Remarks and Overview", **webinar talk,** *IEEE Proceedings Webinar on Surgical Robotics and Computer-Integrated Interventional Medicine*, September 19, 2022
54. "Emerging Control Paradigms", **webinar talk,** *IEEE Proceedings Webinar on Surgical Robotics and Computer-Integrated Interventional Medicine*, September 19, 2022.
55. "Capturing Medtech Opportunities", **invited video panel discussion**, *Asia Summit on Global Health*, November 10, 2022
56. "Inventing the next generation of surgical robots: An international collaboration to improve patient care", **recorded video talk** presented at the *Hong Kong Global Innovation and Technology Summit*, December 15, 2022.
57. "AI in Surgical Procedures", 2023 Hopkins Engineering Exploratory Program (HEEP), March 15, 2023.

TEACHING

Courses Taught or Developed at Johns Hopkins University

	Course Name & description	Year Developed	Years Taught (by me)
600.445/645 now 601.455/655	**Computer-Integrated Surgery (Fall Semester)** This course (originally titled "Quantitative Medical Computing") is a difficult, multidisciplinary course that combines an overview of emerging applications in computer-integrated surgery with instruction in a range of technical sub-disciplines ranging from image processing to modeling to registration to interventional devices. It is taken by upper level-undergraduates and graduate students	1995	1995-2020
600.446/646 now 601.456/486/656	**Advanced Computer-Integrated Surgery (Spring)** This course is a project-oriented seminar course, in which students work in small teams to undertake a substantial implementation effort tied to current research or development activities. Students learn project management and presentation skills as well as gaining practical experience and more in-depth knowledge in a CIS topic.	1996	1996-2021
600.145	**Introduction to Computer-Integrated Surgery (intersession & summer)** This course provides a brief (1 credit) introduction to the basic technology of computer-integrated surgery systems, together with example applications. The material covered is similar in nature to that in 600.445, but in less depth and without intensive mathematics. The course is intended for lower-level undergraduates and for students wanting to learn something about CIS without investing the time required to take 600.445. The summer version of the course is also taken by high school students in special programs.	1999	1999-2006,2008

600.746 now 601.846 cross-listed as 520.746	**Methods in Medical Image Analysis Seminar** This weekly seminar (co-led by Prof. Jerry Prince) focuses on research issues in medical image analysis, including image segmentation, registration, statistical modeling, and applications. It will also include selected topics relating to medical image acquisition, especially where they relate to analysis. The purpose of the course is to provide the participants with a thorough background in current research in these areas, as well as to promote greater awareness and interaction between multiple research groups within the University. Topics vary from year to year. Examples include classic papers in medical imaging, ultrasound imaging, deformable registration, level-set segmentation methods, etc.	2001	2001-2021
500.410	**Surgery for Engineers** This course is a hands-on course on basic surgical technique offered to graduate students and undergraduates in computer-integrated surgery and biomedical engineering. It is taught by a faculty member in the JHU Department of Comparative Medicine. I do not teach this course, but was instrumental in developing the course concept and in getting it started.	1999-2000	
	Winter School for Medical Robotics and Computer-Integrated Interventional Systems (MRCIIS) This is an intensive one week short course for post-graduate and post-doctoral students on medical robotics and computer-integrated interventional medicine. The course includes tutorial lectures and research talks by internationally recognized faculty, lab tours & demonstrations in our new facilities in the Computational Sciences and Engineering Building on the Johns Hopkins Homewood Campus, and a compressed version of Johns Hopkins' unique Surgery for Engineers course. I was the principal organizer of the course, which was team taught by an international team of faculty. The course was first taught in January 2009, with partial support from NSF and IEEE. It was taken by 38 students from around the world, 25 of whom participated in surgery for engineers. The faculty of the school consisted of 19 distinguished researchers from around the world, of whom 13 were from outside JHU. It was subsequently taught in Summer 2010 at the University of Washington and Summer 2012 at the University of Western Ontario; I was a co-organizer.	2008	2009

500.754	**Seminar on Statistical Anatomic Models, Registration, and Reconstruction** This weekly research seminar focuses generally on statistical modeling of anatomic structures, image and model registration, 3D image reconstruction methods, and their interrelationships. We concentrate primarily, though not exclusively, on x-ray based imaging modalities (x-ray fluoroscopy, CT, cone-beam tomography, "hybrid" reconstruction methods, etc.)	2010	2010-2011

Courses Taught or Developed Elsewhere

1. "Computer-Integrated Surgery", 1 week short course taught at Daegu Gyeonbuk Institute of Science and Technology (DGIST) in July 2013.

Postdoctoral Fellows Advised

1. Peter Kazanzides: Developed prototype of Robodoc, the first robot for orthopaedic surgery; 1989-1990 (at IBM Research).
2. Yong-Yil Kim: Developed prototype passive manipulation aid for craniofacial osteotomies; 1989-1990 (at IBM Research).
3. Kreg Gruben: Developed prototype robots for laparoscopic surgery; 1993 (at JHU and IBM Research).
4. Steve Schreiner: X-ray guided robotic system for percutaneous therapy of liver cancer; 1994-1996 (JHU).
5. Payman Sadegh: Optimal planning for HDR brachytherapy; 1998 (JHU)
6. Peter Berkelman: Microsurgical force sensing for steady hand robot; 1999-2000 (JHU, jointly supervised with Louis Whitcomb).
7. Nabil Simaan: Developed snake-like robots for minimally-invasive surgery; 2003-2004 (JHU)
8. Ofri Sadowsky: X-ray hybrid reconstruction and applications to orthopaedic surgery 2008-2009 (JHU)
9. Yoshito Otake: X-ray reconstruction, registration, and application to orthopaedic surgery (with Jeff Siewerdsen) 2008-2010 (JHU)
10. Eric Meisner: Tool trackiing, visual servoing, and experiments in retinal microsurgery (with Greg Hager) 2009 (JHU)
11. Patricio Simari: Radiation oncology "shapes" project (with Misha Kazhdan) 2009-2010 (JHU)
12. Rogerio Richa: Microsurgery Assistant Workstation (with Greg Hager) 2010-2012 (JHU)
13. Marcin Balicki: Robot and computer vision systems for retinal microsurgery and head and neck surgery 2014-2015 (JHU).
14. Andrew Lang: Automatic Vascular Flow Reconstruction with Adaptive Three-Dimensional Doppler (9 month period in 2016-2017) (JHU)
15. Mathias Unberath: Medical image processing, augmented reality, deep learning (now a Research Assistant Professor in CS); 2018 (JHU)
16. Ayushi Sinha: Medical image processing and analysis, with emphasis on sinus modeling; 2018-2019 (JHU)
17. Mahya Shahbazi: Work on a variety of medical robotics projects; 2018-2019 (JHU)
18. Robert Grupp: Work on medical imaging processing, post-dissertation cleanup (co-advised with Mehran Armand); 2020
19. Adnan Munawar: Work on a variety of robotics projects (co-advised with Peter Kazanzides); 2020-2021 (JHU) – Now a research faculty member at JHU
20. Manish Sahu: Work on surgical robotics and machine vision applications in Otolaryngology (co-advised with Francis Creighton; 2022-2023 (JHU)
21. Mohammad Salehizadeh,: Medical robotics; 2022-2023 (JHU)

Ph.D. Theses Advised

As principal advisor

1. Rajesh Kumar, *An Augmented Steady Hand System for Precise Micromanipulation*, Computer Science, The Johns Hopkins University, Baltimore, 2001.
2. Jianhua Yao., *A statistical bone density atlas and deformable medical image registration*, Ph.D. Thesis, Computer Science, The Johns Hopkins University, Baltimore, January 2002.
3. Andrew Bzostek*, Computer-Integrated Needle Therapy Systems: Implementation and Analysis*, Ph.D. thesis, Computer Science, The Johns Hopkins University, Baltimore, March 2005.
4. Ming Li, *Intelligent Robotic Surgical assistance for Sinus Surgery*. Ph.D. thesis, Computer Science, The Johns Hopkins University, Baltimore, August 2005.
5. Ankur Kapoor, *Motion Constrained Control of Robots for Dexterous Surgical Tasks*, Ph.D. Thesis, Computer Science, The Johns Hopkins University, Baltimore, September 2007.
6. Ofri Sadowsky, *Image Registration and Hybrid Volume Reconstruction of Bone Anatomy Using a Statistical Shape Atlas*, Ph.D. Thesis, Computer Science, The Johns Hopkins University, September 2008.
7. Gouthami Chintalapani, *Statistical Atlases of Bone Anatomy and Applications*, Ph.D. Thesis, Computer Science, The Johns Hopkins University, October, 2010.
8. Omar Ahmad, *Volumetric DXA (VXA): A New Method to Extract 3D Information From Multiple In Vivo DXA Images,* Ph.D. Thesis, Computer Science, The Johns Hopkins University, August, 2011.
9. Blake Lucas, *Unifying Deformable Model Representations through New Geometric Data Structures,* Ph.D. Thesis, Computer Science, The Johns Hopkins University, July 2012.
10. Marcin Balicki, *Augmentation Of Human Skill In Microsurgery*, PhD thesis in Computer Science, Johns Hopkins University, Baltimore, Maryland, February 2014.
11. Paul Thienphrapa, *A Minimally Invasive Surgical System for 3D Ultrasound Guided Robotic Retrieval of Foreign Bodies from a Beating Heart*, PhD thesis in Computer Science, Johns Hopkins University, Baltimore, Maryland, March 2014.
12. Wen Liu, *Augmented Reality and Intraoperative C-Arm CBCT for Image-Guided Robotic Surgery,* PhD thesis in Computer Science, Johns Hopkins University, Baltimore, Maryland, June 2014.
13. Kevin Olds, *Robotic Assistant Systems for Otolaryngology-Head and Neck Surgery*, PhD thesis in Biomedical Engineering, Johns Hopkins University, Baltimore, March 2015.
14. Seth Billings, *Probabilistic Feature-Based Registration for Interventional Medicine,* PhD thesis in Computer Science, Johns Hopkins University, Baltimore, Maryland, August 2015.
15. Ayushi Sinha, *Deformable registration using shape statistics with applications in sinus surgery*, PhD thesis in Computer Science, Johns Hopkins University, Baltimore, May 2018.
16. Preetham Chalasani*, Complementary Situational Awareness For Intelligent Telerobotic Surgical Assistant Systems*, Ph.D. Thesis in Computer Science, Johns Hopkins University, Baltimore, October 2018.
17. Robert Grupp, *Computer-Assisted Fluoroscopic Navigation for Orthopaedic Surgery*, PhD thesis in Computer Science, Johns Hopkins University, Baltimore, February 2020.
18. Xingtong Liu, *Towards Quantitative Endoscopy with Vision Intelligence*, Ph.D. thesis in Computer Science, Johns Hopkins University, September 2021.
19. Zhaoshuo (Max) Li, *Towards Vision-Guided Skull Base Surgery*. PhD thesis in Computer Science, Johns Hopkins University, May 2023. (co-advised with Mathias Unberath)
20. Henry Phalen*, Image-Guided High-Dexterity Robotic Systems for Minimally Invasive Orthopaedic Surgery*, PhD thesis in Mechanical Engineering, The Johns Hopkins University, Baltimore, September 2023

As secondary advisor or reader (incomplete list)

1. David LaRose, *X-ray/CT Registration using Accelerated Volume Rendering*, Ph.D. Thesis, Computer Science, Carnegie Mellon University, April 2001. (**Reading Committee Member)**
2. Ashraf Mohamed, *Combining Statistical and Biomechanical Models for Estimation of Anatomical Deformations*, Ph.D. Thesis, Computer Science, Johns Hopkins University, July, 2005. (**Co-advisor and Reading Committee Member)**

3. Sheng Xu, *Organ motion compensation in computer integrated surgery,* Ph.D. Thesis, Computer Science, Johns Hopkins University, July, 2005. (**Co-advisor and Reading Committee Member**)
4. Krishna Ramamurthy, *Cone-Beam Tomography Using C-Arm X-ray Projections: Complete Trajectories and Integration of Prior CT Information,* Ph.D. Thesis, Electrical and Computer Engineering, The Johns Hopkins University, Baltimore, April 2006. **(Reading Committe Member)**
5. Emad Boctor, *Enabling Technologies for Ultrasound Imaging in Computer-Assisted Intervention*, Ph.D. Thesis, Computer Science, The Johns Hopkins University, Baltimore, October 2007. (**Co-advisor and Reading Committee Member**)
6. Panadda Marayong, *Motion Control Methods for Human-Machine Cooperative Systems,* Ph.D. Thesis, Mechanical Engineering, Ph.D. Thesis, Computer Science, The Johns Hopkins University, Baltimore, August 2007. (**Reading Committee Member**)
7. Ameet Jain, *Computation of 3D Implant Coordinates for Prostate Brachytherapy*, Ph.D. Thesis, Computer Science, The Johns Hopkins University, Baltimore, September 2007. (**Co-advisor and Reading Committee Member**)
8. Lotta Ellingsen, *Hybrid Deformable Image Registration - with Applicaton to Brains, Pelvises, and Statistical Atlases,* Ph.D. Thesis, Electrical and Computer Engineering, The Johns Hopkins University, Baltimore, December 2007. **(Reading Committe Member)**
9. Robert Webster, *Design and Mechnanics of Continuum Robots for Surgery,* Ph.D. Thesis, Mechanical Engineering, Ph.D. Thesis, Computer Science, The Johns Hopkins University, Baltimore, December 2007. **(Reading Committee Member**)
10. Yiqiang Zhan, *Advanced Image Analysis Methods for the Diagnosis of Prostate Cancer*, Ph.D. thesis in Computer Science, Johns Hopkins University, Baltimore, 2007. **(Reading Committee Member**)
11. Jeffrey Stoll, *Ultrasound-based Navigation for Minimally Invasive Medical Procedures*, Ph. D. thesis in Mechanical Engineering, Boston University, 2007. **(Reading Committee Member**)
12. Lawton Verner, *Sensor/Actuator Asymmetries in Telemanipulators, Ph.D. thesis in Mechanical Engineering*, Johns Hopkins University, Baltimore, 2009.**(Reading Committee Member)**
13. Nicholas Patronik, *A Miniature Mobile Robot for Precise and Stable Access to the Beating Heart*, Ph.D. thesis in Robotics, Carnegie-Mellon University, 2008.**(Reading Committee Member**)
14. Gabriel Brisson, *The Precision Freehand Sculptor: A Robotic Tool for Less Invasive Joint Replacement Surgery*, Ph.D. thesis in Robotics, Carnegie-Mellon University, 2008.**(Reading Committee Member**)
15. Gregory Fischer, *Enabling Technologies for MRI-Guided Interventional Procedures, Ph.D. thesis in Mechanical Engineering*, Johns Hopkins University, Baltimore, 2008.**(Reading Committee Member)**
16. Orcun Goksel, *Meshing and Rendering of Patient-Specific Deformation Models with Application to Needle Insertion Simulation*, Ph.D. thesis in Electrical and Computer Engineering, University of British Columbia, Vancouver, 2010. **(External Reader**)
17. Michael D. Kutzer, *Advancements in Cooperative Robotics*, Ph.D. Thesis in Mechanical Engineering, May 2012, **(Reading Committee Member)**
18. Daniel Mirota, *Video-Based Navigation with Application to Endoscopic Skull Base Surgery*, Ph.D. Thesis in Computer Science, July 2012 **(Advisory Committee Member)**.
19. Tian Xia, *Toward Model Driven Robotic Assistance in Human-Robot Collaboration Systems*, Ph. D. Thesis in Computer Science, The Johns Hopkins University, 2012 **(Reading Committee Member)**
20. Lejing Wang, *Novel Techniques for Integrating Video Augmented X-ray Imaging into Orthopedic and Trauma Surgery*, Ph.D. Thesis in Computer Science, Technical University of Munich, 2012 **(External Examiner)**
21. James Gwilliam, *Tactile Sensing and Display for Robot-Assissted Minimally Invasive Surgery: Detecting Lumps in Soft Tissue,* Ph.D. Thesis in Mechanical Engineering, May 2013 **(Reading Committee Member)**.
22. Ehsan Basafa, *Computer-Assisted Femoral Augmentation for Osteoporotic Hip Fracture Prevention,* Ph. D. Thesis in Mechanical Engineering, Johns Hopkins University, September 2013 **(Reading Committee Member)**.
23. Ioana Fleming, *Robust Displacement Estimation for Ultrasound Elastography and Thermal Imaging*, Ph. D. Thesis in Computer Science, 2014 (**Reading Committee Member)**.
24. Chunwoo Kim, *Image Guided Robots for Urology,* Ph.D. Thesis in Mechanical Engineering, Johns Hopkins University, March 2014 **(Reading Committee Member)**.

25. Ryan J. Murphy, *Analysis and Control of a Variable-Curvature Continuum Manipulator for the Treatment of Osteolysis*, PhD Thesis in Mechanical Engineering, Johns Hopkins University, May, 2015 **(Reading Committee Member).**
26. Min Yang Jung, *State-based Safety of Component-based Medical and Surgical Robot Systems,* Ph.D. thesis in Computer Science, The Johns Hopkins University, May 2015 **(Secondary Advisor and Reading Committee Member)**.
27. Hyun Jae Kang, *Medical Ultrasound Imaging and Interventional Component (MUSiiC) Framework for Advanced Ultrasound Image-guided Therapy*, Ph.D. Thesis in Computer Science, Johns Hopkins University, July 2015 **Secondary Advisor and Reading Committee Member)**.
28. Xinchi He, *Force Sensing Augmented Robotic Assistance for Retinal Microsurgery,* Ph.D. thesis in Mechanical Engineering, The Johns Hopkins University, July 2015. **Secondary Advisor and Reading Committee Member).**
29. Amod Jog, *Image Synthesis in Magnetic Resonance Neuroimaging*, Ph.D. Thesis in Computer Science, Johns Hopkins University, February 2016 **(Reading Committee Member)**.
30. Mahmoud Mahmoud, *Methods for Medical Image Retrieval and Management Using De-duplicated DICOM Formats*, Ph.D. Thesis in Computer Science, February 2016 (**Reading Committee Member).**
31. H. Tutkun Sen, *Robotic Assisted Ultrasound Guidance and Target Monitoring during Radiotherapy*, , Ph.D. Thesis in Computer Science, February 2016 (**Reading Committee Member).**
32. Saman Nouranian*, Information Fusion for Prostate Brachytherapy Planning,* Ph.D. Thesis in Electrical & Computer Engineering, University of British Columbia, April 2016 (**External Reading Committee Member**).
33. Haluk Tokgozoglu, *Modeling the Representation of Medial Axis Structure in Human Ventral Pathway Cortex*, Ph.D. Thesis in Computer Science, Johns Hopkins University, July 2016 **(Reading Committee Member)**.
34. Nishikant Deshmukh, *Real-Time Elastography Systems*, Ph.D. Thesis in Computer Science, Johns Hopkins University, November 2016, **(Secondary Advisor and Reading Committee Member)**.
35. Sueerat Reaungamornrat, *Deformable Image Registration for Guidance using Intraoperative Cone-Beam CT*, Ph.D. Thesis in Computer Science, Johns Hopkins University, December 2016, **(Secondary Advisor and Reading Committee Member)**.
36. Ali Uneri, *Imaging and Registration for Surgical Guidance: Systems and Algorithms for Intraoperative C-Arm 2D and 3D Imaging,* Ph.D. Thesis in Computer Science, Johns Hopkins University, December 2016, **(Secondary Advisor and Reading Committee Member)**.
37. Anand Malpani, *Automated Virtual Coach for Surgical Training*, Ph.D. Thesis in Computer Science, Johns Hopkins University, February 2017, **(Secondary Advisor and Reading Committee Member)**. Principal advisor was Greg Hager.
38. Berk Gonenc, Force-Sensing-Based Multi-Platform Robotic Assistance for Vitreoretinal Surgery, Ph.D. thesis in Mechanical Engineering, Johns Hopkins University, May 2017. **(Secondary Advisor and Reading Committee Member)**. Principal advisor was Iulian Iordachita.
39. M. Ayad, A Study of Image-based C-arm Tracking Using Minimal Fiducials, Ph.D. thesis in Computer Science, Johns Hopkins University, May 2017. **(Reading Committee Member).** Principal Advisor was Austin Reiter.
40. Alexis Cheng, *Developing Ultrasound-Guided Intervention Technologies Enabled by Sensing Active Acoustic and Photoacoustic Point Sources*, Ph.D. thesis in Computer Science, Johns Hopkins University, Baltimore, July 2017. **(Secondary Advisor and Reading Committee Member)**. Principal advisor was Emad Boctor.
41. Haichong (Kai) Zhang, *Enabling Technologies for Co-robotic Translational Ultrasound and Photoacoustic Imaging*, Ph.D. thesis in Computer Science, Johns Hopkins University, September 2017. **(Secondary Advisor and Reading Committee Member)**. Principal advisor was Emad Boctor.
42. Bong Joon (Nathan) Cho, *Forward and Inverse Treatment Planning Solutions for Small Animal Radiation Research*, Ph.D. Thesis in Computer Science, Johns Hopkins University, October 2017. **(Secondary Advisor and Reading Committee Member).** Principal Advisor was Peter Kazanzides.
43. Zihan Chen, *A Scalable, High-Performance, Real-Time Control Architecture with Application to Semi-Autonomous Teleoperation*, Ph.D. thesis in Computer Science, Johns Hopkins University, October 2017. **(Secondary Advisor and Reading Committee Member).** Principal Advisor was Peter Kazanzides.

44. Changhan Jun, *Development of medical devices and image-guided robots for needle based interventions*, Ph.D. thesis in Mechanical Engineering, Johns Hopkins University, October 2017. **(Reading Committee Member).** Principal advisor was Dan Stoianovici.
45. Arun Srivatsan Rangaprasad, *Probabilistic Approaches for Pose Estimation*, PhD Thesis in Robotics, Carnegie Mellon University, May 2018 (**Thesis Committee Member**). Principal Advisor was Howie Choset.
46. Sabine Thuerauf, *Accurate and Efficient Calibration of a Robotic C-Arm System Based on X-Ray Observations*, Ph.D. Thesis in Informatics, Technical University of Munich, September 2018 (**External Reviewer)**. Principal advisor was Alois Knoll.
47. Vishwa Parekh, *Integrated Graph Theoretic, Radiomics, and Deep Learning Framework for Personalized Clinical Diagnosis, Prognosis, and Treatment Response Assessment of Body Tumors*, Ph.D. Thesis in Electrical and Computer Engineering, Johns Hopkins University, October 2018 (**Reading Committee Member**). Principal advisor was Michael Jacobs.
48. Farshid Alambeigi, *Dexterity and Autonomy in Minimally Invasive Surgical Robotics Interventions*, Ph.D. Thesis in Mechanical Engineering, The Johns Hopkins University, May 2019 (**Thesis Committee Member**). Principal advisor was Mehran Armand.
49. Sungwan Lim, *Image-Guided Robotic Interventions for Core Needle Biopsy*, Ph.D. Thesis in Mechanical Engineering, The Johns Hopkins University, July 2019 (**Reading Committee Member**). Principal advisor was Dan Stoianovici.
50. Younsu Kim, *Towards modular ultrasound system for medical intervention and image guided therapy : Ultrasound temperature monitoring*, Ph.D. Thesis in Computer Science, Johns Hopkins University, February 2020 (**Thesis Committee Member**). Principal advisor was Emad Boctor.
51. Shahriar Sefati, *A Dexterous Surgical Robotic System for Autonomous Minimally Invasive Orthopaedic Interventions*, Ph.D. Thesis in Mechanical Engineering, Johns Hopkins University, March 2020. (**Thesis Committee Member**). Principal advisor was Mehran Armand.
52. Jie-Ying Wu, *Using High-Level Processing of Low-Level Signals to Actively Assist Surgeons with Intelligent Surgical Robots*, PhD thesis in Computer Science, Johns Hopkins University, August 2021. **Thesis Committee Member**). Principal Advisor was Peter Kazanzides
53. Cong Gao, *Fluoroscopic Navigation for Robot-Assisted Orthopedic Surgery,* PhD Thesis in Computer Science, Johns Hopkins University, June 2022. (**Thesis Committee Member**). Co-Principal Advisors were Mehran Armand and Mathias Unberath.
54. M. Bakhtiarinejad, *Robot-Assisted Orthopaedic Surgery Interventions with Biomechanical Guided Planning and Analysis of Novel Implant Designs*, PhD thesis in Mechanical Engineering, Johns Hopkins University, Baltimore, March 2023. **(Thesis Committee Member).** Principal Advisor was Mehran Armand.
55. E. Dimitrakakis, *Handheld Robotic Instruments for Endoscopic Neuros*urgery, PhD thesis in Computer Science, University College London, London, September 2023. **(External Reviewer)**

M.S. Theses Advised

As principal advisor

1. Aaron Barnes, *A modular robotic system for precise minimally invasive surger*y, MS Thesis, Mechanical Engineering, The Johns Hopkins University, Baltimore, 1999.
2. Jonathan Lazarus, *Computer-Assisted Vertebroplasty*, MS Thesis, Computer Science, The Johns Hopkins University, Baltimore, 2000.
3. Randall Goldberg, *A Modular Robotic System for Ultrasound Image Acquisition*, M.S. Thesis, Mechanical Engineering, The Johns Hopkins University, Baltimore, 2001.
4. Adam Morris, *Bone Registration and Tracking using an optical tracking system*, M.S. Thesis, Computer Science, The Johns Hopkins University, Baltimore, 2002.
5. Joshua Leven, *A Telerobotic Surgical System with Integrated Robot-Assisted Laparoscopic Ultrasound Capability,* Computer Science, The Johns Hopkins University, Baltimore, May 2005.
6. Gregory Fischer, *Electromagnetic Tracker Characterization and Optimal Tool Design (with Application to ENT Surgery),* Mechanical Engineering, The Johns Hopkins University, Baltimore, May 2005.

7. Barry Herman, *On the Role of Three Dimensional Visualization for Surgical Applications in Interactive Human Machine Systems*, Computer Science, The Johns Hopkins University. May 2005.
8. Gorkem Sevinc, *Integration and Evaluation of Interactive Speech Control in Robotic Surgery*, MS thesis in Computer Science, Johns Hopkins University, Baltimore, Maryland, 2010.
9. Orhan Ozguner, *Virtual Fixtures for Teleoperation* , MSE Thesis in Computer Science, Johns Hopkins University, Baltimore, Maryland, 2013.
10. Saumya Gurbani, *Submillimeter Fiber-Based Endomicroscopy using Optical Coherence Tomography for Cochlear Implant Surgery*, MS Thesis in Biomedical Engineering, 2013 (co-advisor).
11. Mehmet Gulsun, *CTA Coronary Labeling Through Efficient Geodesics Between Trees Using Anatomy Priors*, MS Thesis in Computer Science, The Johns Hopkins University, October 2014.
12. P. Lakshminarayanan, *Radio-morphology: Parametric Shape-Based Features in Radiotherapy*, MS thesis in Biomedical Engineering, Johns Hopkins University, December 2017.
13. Kevin Gilboy, Robotic Ultrasound Tomography and Collaborative Control, MS Thesis in Engineering, Johns Hopkins University, May 2020 (co-principal advisor with Emad Boctor)
14. Can Kocabalkanli, Autonomously Retractable Endoscope Holder for Otologic and Associated Procedures, MS Thesis in Robotics, Johns Hopkins University, May 2020 (co-principal advisor with Francis Creighton)
15. Hongchao Shu, TWIN-S: A Digital Twin Paradigm for Skull Base Surgery, Masters thesis in Computer Science, Johns Hopkins University, Baltimore, May 2023 (co-advised with Mathias Unberath)

Supervised Internships Counting Toward Robotics MS Degree.

1. Vishnu Kolal, "Virtual Fixture Assisted Craniotomy on Galen Robot", with Galen Robotics, Fall 2022

Research Funding

Current

Title: **Research and Development on a Novel Robotic System for Head and Neck Surgery**
Dates: 02/01/2017-3/31/2025
Grantor: Galen Robotics, Inc.
Contract Number: 90072284
Award Amount: $1,363,808
Summary: The primary purpose of this project is to cover activities by JHU in collaborating with on-site Galen engineers in developing research prototypes of the REMS/Galen robot, to develop custom surgical tools and applications using the robot, and to support preclinical evaluation of the system.
Role: Principal Investigator

Title: **Multi-Scale Medical Robotics Center**
Dates: 06/01/2020-05/31/2025
Grantor: Multi-Scale Medical Robotics Center, Ltd.
Award Number: Agreement
Award Amount: $2,595,971
Role: Principal Investigator for JHU subcontract
Summary: This is a research subcontract with a large multi-institutional research center led by the Chinese University of Hong Kong. JHU's role focuses on image-guided robotic interventions with the development of image-based automation in robotic surgery, high performance robotic systems for intra-operative MRI-guided interventions, image-guided robotic platform for minimally invasive orthopaedic surgery, low-cost surgical robotic arm system for universal surgeries.

Title: **Automating Mosquito Microdissection for a Malaria PfSPZ Vaccine**
Dates: 05/01/2021-04/30/2024
Grantor: Subcontract from Sanaria on an NIH SBIR
Award Number: NIH 2 R44 AI134500-04 A1
Award Amount: $1,134,960 (JHU portion)
Summary: This project builds upon our earlier and ongoing collaboration with Sanaria, Inc. in developing production processes for a malaria vaccine. JHU's roles include assisting in translation of our previously developed prototypes into GMP production and in developing a more fully automated robotic system to greatly increase production rates.
Role: Principal Investigator for JHU sub-award

Title: **Improved Surgical Navigation Using Video-CT Registration**
Dates: 07/05/2021-03/31/2025
Grantor: NIH
Award Number: NIH R01EB030511
Award Amount: $2,457,951
Summary: This project extends earlier work in which 3D sinus anatomy of individual patients is recovered from untracked sinus endoscopy video and registered to patient-specific CT images or to statistical models for the purpose of surgical navigation. Our solution relies on advances along two fronts. First, we will develop a complete navigation solution based on video-CT registration that is robust to discrepancies between the observed video images and the prior CT model. Solving this problem will rely on advances in computer vision for modeling change detection and the use of learned domain-specific feature representations, which our group has also recently developed. Second, in our

prior work we have demonstrated a method to perform dense three-dimensional surface reconstruction of sinus anatomy from video images. In this project, we propose to take the next step and extend navigation with reconstruction from video sequences. We introduce a novel volumetric signed distance model that is compatible with CT images. This will allow us to combine video-based reconstruction with the prior CT model, thus creating a complete navigation solution that can model and update the anatomic model as the procedure progresses

Role: Co-Investigator (PI is Greg Hager)

Title: **Robotic System for Spinal Decompression and Interbody Fusion**
Dates: 09/01/2021-08/31/2025
Grantor: NIH
Award Number: NIH R01 AR080315
Award Amount: $2,850,508
Summary: This project aims to develop a surgical robotic system integrated with continuum dexterous manipulators (CDM), novel imaging and visualization capabilities to perform complex tasks in minimally-invasive spine (MIS) surgery such as spinal decompression and transforaminal lumbar interbody fusion (TLIF) with less damage to surrounding tissues.
Role: Co-Investigator (PI is Mehran Armand)

Title: **Image-based Fluoroscopic Navigation with Biomechanical Feedback for Orthopaedic Surgery**
Dates: 12/01/2021-11/30/2025
Grantor: NIH
Award Number: NIH R01 AR080315
Award Amount: $2,816,081
Summary: This application aims at developing and clinically evaluating a fluoroscopic guided navigation system that performs three-dimensional, real-time, intra-operative biomechanical analysis, and bone fragment tracking with a focus on orthopaedic surgery. While the immediate focus here is periacetabular osteotomy (PAO) surgery, applications of this research can be extended to other types of hip osteotomies, knee osteotomies, joint osteotomies, total hip replacement, trauma, fracture repair, and hip resurfacing techniques.
Role: Co-Investigator (PI is Mehran Armand)

Title: **Enabling Technology for Safe Robot-assisted Surgical Micromanipulation**
Dates: 09/01/2021-08/31/2024
Grantor: NIH
Award Number: NIH 2 R01 EB023943-04A1
Award Amount: $1,579,353
Summary: The goal of this project is to develop and evaluate enabling technology for safe and reliable bilateral, semi-autonomous robotic assistance integrated with force sensing instruments to assist the surgeon with sensorimotor guidance for safe retinal vein cannulation.
Role: Co-Investigator (PI is Iulian Iordachita)

Title: Discovery: Simulation Assisted Navigation for Skull Base Surgery
Dates: 07/01/2023-06/30/2024
Grantor: Johns Hopkins University
Award Number: 1207350596
Award Amount: $99,996

Summary: Our goal is to improve the safety and efficacy of skull-base surgeries. To achieve this goal, we shall develop an intuitive, interactive and real-time guidance system augmenting surgical skills without altering the clinical workflow
Role: Co-Investigator (PI is Adnan Munawar)

Title: REU Site: Leveraging AI in Sensing, Robotics, and Healthcare (AI-CARE)
Dates: 04/01/2024-03/31/2027
Grantor: NSF
Award Number: N/A
Award Amount: $460,229
Summary: This program addresses a vital national need to improve the delivery of healthcare by developing new sensing, imaging, algorithms, and medical robotics systems, as well as techniques designed to enhance the ability of clinicians to introduce, plan, execute and assess medical procedures. By recruiting from and partnering with LSAMP, McNair, SWE, SHPE and other similar programs, minority- serving institutions and community colleges, we will help develop a pipeline of qualified, diverse individuals who will contribute to the workforce in the area of STEM, particularly in the interdisciplinary subjects encountered in data-science and technology enhanced biomedical research, clinical interventions, and basic biological and life sciences. The participants will be well trained in communications and research ethics, which are essential for success in today's biotechnology and bioscience work and marketplace
Role: Co-Investigator (PI is Ralph Etienne-Cummings)

Completed

Title: **Virtual Fixtures for Craniosynstosis Surgery**
Dates: 01/04/2021-01/03/2022 (no-cost extension into 2023)
Grantor: Intuitive Surgical, Inc
Award Amount: $30,000
Summary: This is the JHU portion of a small project with Toronto Children's Hospital (SickKids) to develop virtual fixtures for craniosynstosis surgery The contract to SickKids and the subcontract to JHU are separate.
Role: PI for the JHU portion
Title: **Enabling technology for image-guided robot-assisted sub-retinal injections**
Dates: 9/20/2019-6/30/2022
Grantor: National Institutes of Health
Award Number: 1R01EB025883-01A1
Award Amount: $317,666 (Direct, Year 1 only)
Role: Co-Investigator (Principal Investigator is Iulian Iordachita)
Summary: The goal is to develop and test a cooperatively controlled robotic system that in conjunction with force-sensing microsurgical instruments guided by 4D intraoperative Optical Coherence Tomography could enable safe and reliable access to the subretinal space.

Title: **SBIR Phase II - Automating Mosquito Microdissection for a Malaria PfSPZ Vaccine**
Dates: 06/20/2017-05/31/2021
Grantor: Subcontract from Sanaria on and NIH SBIR
Award Number: NIH 1 R44 AI134500-01
Award Amount: $898,928.00 (JHU portion)
Summary: This project builds upon our earlier and ongoing collaboration with Sanaria, Inc. in developing production processes for a malaria vaccine. JHU's roles include assisting in

translation of our previously developed prototypes into GMP production and in developing a more fully automated robotic system to greatly increase production rates.
Role: Principal Investigator for JHU sub-award
JHU Faculty: Russell Taylor, Gregory Chirikjian, Iulian Iordachita

Title: **Enabling Technology for Safe Robot-Assisted Micromanipulation**
Dates: 3/15/2017-1/31/2021
Grantor: National Institutes of Health
Award Number: 1R01EB023943-01
Award Amount: $1,017,478
Summary: The goal is to develop a cooperatively controlled robotic system with enhanced sensorimotor capabilities that in conjunction with multifunction force-sensing microsurgical instruments could enable safe robot-assisted retinal surgery[1]
Role: Co-Investigator (PI is Iulian Iordachita)

Title: **NRI: Collaborative Research: Software Framework for Research in Semi-Autonomous Teleoperation**
Dates: 10/01/16-09/30/20
Grantor: NSF 1637789
Award Amount: $978,300
Summary: This work focuses on development of open source software for teleoperated robots capable of sharing control between the human operator and the robotic system. Although the main focus is on teleoperated surgical robot research platforms such as the daVinci Research Kit (dVRK) and the Raven system, the software infrastructure is broadly applicable to many platforms.
Role: Co-investigator (Principal Investigator is Peter Kazanzides)

Title: **MRI Compatible Body-Mounted Robot to Streamline Pediatric Shoulder Arthrography**
Dates: 09/15/16-06/30/20
Grantor: NIH 1R01 EB02003-01A1
Award Amount: $320,120
Summary: This is a small project in partnership with Children's National Medical Center to develop a robotic device for in-MRI arthrography
Role: Co-investigator (Principal Investigator is Iulian Iordachita)

Title: **NRI: Large: Collaborative Research: Complementary Situational Awareness for Human-Robot Partnerships**
Dates: 10/01/2013-09/30/2019
Grantor: National Science Foundation
Award number: NSF IIS-1327657
Award amount: $1,648,928
Summary: This work will advance human-robot partnerships by establishing a new concept called complementary situational awareness (CSA), which is the simultaneous perception and use of the task environment, using focusing applications in medical robotics. Our partner institutions for this award are Vanderbilt University (N. Simaan) and Carnegie Mellon University (H. Choset)
Role: Principal Investigator
JHU Faculty: Russell Taylor (PI), Peter Kazanzides, Anton Deguet (Research Engineer)

Title: **A New robotic platform for image-guided orthopaedic surgery**
Dates: 5/1/2014-12/31/2018
Grantor: Think Surgical (Subsidiary of Curexo Technology Corp.)

Award Amount: $620,000
Summary: This work comprises several interrelated projects developing new technology and applications for a surgical robotics company.
Role: Co-investigator (Principal Investigator is Peter Kazanzides)

Title: Image-Guided Workstation and Tools for the Treatment of Bone Defects
Dates: 9/30/2013-11/30/18 (NCE)
Grantor: National Institutes of Health
Award number: NIH 1 R01 EB016703
Award amount: $492,124 (estimated sub-allocation from JHU APL)
Summary: The goal of this project is to develop a prototype robotically-assisted, less-invasive surgical workstation for preoperative planning, and real-time intraoperative monitoring, navigation, and updating of plans during hip revision surgery and for the treatment of osteolytic bone defects.
Role: Co-Investigator (Principal Investigator is Mehran Armand)

Title: X-Ray Image-based Biomechanical Guidance for Hip Surgery
Dates: 4/1/2015 -3/31/2018 (NCE)
Grantor: NIH/NIBIB R21 EB020113-01
Award Amount: $275,000
Summary: The goal of this work is to develop and evaluate a fluoroscopic guided system that performs three dimensional, real-time, intra-operative biomechanical analysis and fragment tracking to help surgeons improve the outcome of the periacetabular osteotomy (PAO).
Role: Co-investigator (Principal Investigator is Mehran Armand)

Title: Enhanced Navigation for Endoscopic Sinus Surgery Through Video Analysis
Dates: 7/1/2012-6/30/2017
Grantor: National Institutes of Health
Award number: R01 EB015530
Award amount: $1,828,944
Summary: This project will provide new registration and visualization tools for sinus surgery using widely available high-definition endoscopic video. These tools will provide higher accuracy navigation to the surgeon, and will make it possible to accurately measure change as surgery progresses. The impact of these tools will be to enhance patient safety, reduce operative time, and reduce the need for intraoperative CT or cone beam imaging.
Role: Co-Investigator (Principal Investigator is Greg Hager)

Title: X-Ray Image-based Biomechanical Guidance for Hip Surgery
Dates: 4/1/2015 -3/31/2017
Grantor: NIH/NIBIB R21 EB020113-01
Award Amount: $275,000
Summary: The goal of this work is to develop and evaluate a *fluoroscopic guided system* that performs three dimensional, real-time, intra-operative biomechanical analysis and fragment tracking to help surgeons improve the outcome of the periacetabular osteotomy (PAO).
Role: Co-investigator (Principal Investigator is Mehran Armand)

Title: Automatic Vascular Flow Reconstruction with Adaptive Three-Dimensional Doppler
Dates: 09/15/16-09/14/17
Grantor: Sonavex, Inc. (Subcontract from Sonavex on an NSF SBIR)
Award Amount: $66,499 (JHU subcontract portion)
Summary: The goal of this subcontract from Sonavex, Inc., under an NSF Phase II SBIR grant, is to develop a novel method for ultrasound-based detection of incipient post-operative blood clots. The JHU project includes work on phantom experiments and simulation studies

Role: Principal Investigator for JHU portion of SBIR to Sonavex

Title: **Removing Salivary Glands from Mosquitoes**
Dates: 7/1/2015-6/30/2017
Grantor: Sanaria, Inc.
Award Amount: $80,000
Summary: This was a small project to assist in developing production processes for a malaria vaccine.
Role: Principal Investigator

Title: **OCT-Guided Free-Hand Semi-Automated Microsurgical Tool for Enhanced Retinal Surgery Applications**
Dates: 08/01/2011-07/31/2017 (NCE)
Grantor: NIH 1 R01 EY021540 - 01
Award Amount: $1,770,283
Summary: This project addresses fundamental limitations in current vitreoretinal surgery by developing functional free-hand surgical tools that could empower micro-surgeons to achieve surgical objectives, diminish surgical risk and improve outcomes in all microsurgical fields
Role: Co-investigator (Principal Investigator is Jin Kang)

Title: **The Robotic ENT Microsurgery System [REMS]**
Dates: 8/24/2015-5/24/2016
Grantor: The Maryland Innovation Initiative
Award Amount: $100,000
Summary: This is a small development grant to pay engineering salaries and some materials costs associated with development of a novel microsurgery system primarily intended for head and neck microsurgery,
Role: Principal Investigator

Title: **Interventional PhotoAcoustic Surgical System (i-PASS)**
Dates: 4/1/2013-3/31/2016
Award Number: NIH 1 R21 EB015638
Award Amount: $235,987
Summary: The goal of this project is to develop a feasibility prototype of a novel system that exploits the photoacoustic effect to promote intraoperative video-to-ultrasound registration and guidance in minimally invasive interventions.
Role: Principal Investigator

Title: **The Robotic ENT Microsurgery System [REMS]**
Dates: 9/2015-12/2015
Grantor: Cohen Fund (Johns Hopkins University)
Award Amount: $25,000
Summary: This was a small development grant to pay engineering salaries and some materials costs associated with development of a novel microsurgery system primarily intended for head and neck microsurgery,
Role: Principal Investigator

Title: **Microsurgical Assistant Workstation**
Dates: 6/1/08-5/30/14
Grantor: National Institutes of Health
Award number: BRP 1 R01 EB 007969-01 A1
Award amount: $5,795,410
Summary: This Bioengineering Research Partnership (BRP) focuses the efforts of highly qualified engineers and scientists from JHU (lead institution), Columbia and CMU, as well as surgeons from the JHU School of Medicine, to overcome human limitations in surgical practice. This project

proposes to develop novel core technology and microsurgical tools with unique capability, as well as integrate computer assist systems. The effort will generate a computer assisted human user with enhanced microsurgical ability.
Role: Principal Investigator

Title: **OCT Imaging and Assistive Systems for Cochlear Implant Surgery**
Dates: 1/1/2012-1/15/2015
Grantor: Cochlear Corporation
Award amount: $230,000
Summary: This is an exploratory project with Cochlear Corporation to develop and evaluate novel methods for assisting a surgeon in inserting a cochlear implant into the cochlea without damage to the cochlea
Role: Principal Investigator

Title: **SBIR Phase II: Active Device for Reliable Cleaning of Feeding Tubes**
Dates: 9/13/12-9/12/13
Grantor: Actuated Medical (Subcontract from NSF SBIR)
Award number: 5026-501
Award amount: $99,785
Summary: This NSF SECO Phase II Supplement program will develop the Brain Shunt In-situ Clearing System - BASIC™ - a simple, safe, and minimally invasive device for percutaneous restoration of patency to occluded cerebrospinal fluid (CSF) shunts.
Role: Principal Investigator

Title: **Richard A. Swirnow Computer-Integrated Surgical and Interventional Systems Mock Operating Room**
Dates: 2008-2012
Grantor: Swirnow Family Foundation
Award amount: $400,000 ($80,000/year)
Summary: This is a charitable donation from the Swirnow Foundation to Johns Hopkins University for a computer-integrated "mock operating room" for systems-integration research and education in the Computational Sciences and Engineering Building on Johns Hopkins' Homewood Campus.
Role: Principal Investigator

Title: **North-American School on Medical Robotics and Computer-Integrated Interventional Systems (NAS MR/CIIS)**
Dates: 10/1/2008-9/30/2011
Grantor: NSF
Award amount: $50,000
Summary: This is a small grant from NSF to help support the Winter School in January 2009 and similar activities in the following year. The School was an intensive 1 week short course for post-graduate and post-doctoral students on medical robotics and computer-integrated interventional medicine. The course includes tutorial lectures and research talks by internationally recognized faculty, lab tours & demonstrations in our new facilities in the Computational Sciences and Engineering Building on the Johns Hopkins Homewood Campus, and a compressed version of Johns Hopkins' unique Surgery for Engineers course. For the following year the money will be used to subsidize student expenses for a similar school elsewhere.
Role: Co-principal investigator (with Ralph Etienne-Cummings)

Title: **MRI: Development of Infrastructure for Integrated Sensing, Modeling, and Manipulation with Robotic and Human-Machine Systems**
Dates: 9/1/07-8/31/2011
Grantor: National Science Foundation
Award number: CNS Major Research Instrumentation
Award amount: $1,994,353

Summary: The focus of the grant is construction of two complementary robotics platforms for robotics research. My role is essentially consulting.
Role: Co-investigator (PI is A. Okamura)

Title: 3D Volumetric and Biomechanical Models of the Proximal Femur from DXA Projection Images
Dates: 10/1/05-10/1/11
Grantor: Hologic, Inc
Award amount: $388,924
Summary: This project combines development of a statistical atlas of the proximal femur with deformable 2D-3D registration to create patient-specific "virtual CT" volumetric models based on a small number of Dual-Energg X-ray (DXA) images. One potential application of this work would be biomechanical modeling to assess fracture risk of patients undergoing DXA screening.
Role: Principal investigator

Title: High-Performance Cone-Beam CT Guidance of Head and Neck Surgery
Dates: 08/01/07-07/31/11
Grantor: National Institutes of Health
Award number: 1- R01-CA127444
Summary: Development of an integrated cone-beam CT guidance system for head and neck surgery. Quantitation of surgical performance improvement under various guidance modalities. Deployment in clinical research trials.
Role: Co-investigator (PI is J. Siewerdsen)

Title: Computer-assisted Hip Osteotomy Surgery with Real-Time Biomechanical Guidance
Dates: 10/01/07-9/30/10
Grantor: National Institutes of Health
Award number: 1 R01 EB006839-01A1
Award amount: $212,220 (subaward)
Summary: Our goal is to develop and evaluate a real-time, intra-operative biomechanical guidance system that may improve the outcome of image-guided Periacetabiular osteotomy surgery
Role: Co-investigator (PI is M. Armand)

Title: Image-Guided Osteoporotic Bone Augmentation
Dates: 08/01/07-07/31/10
Grantor: National Institutes of Health
Award number: NIH 1 R21 EB007747-01
Award amount: $448,003
Summary: The long-range goal of this project is to develop an image-guided workstation with biomechanical planning and intraoperative updates for surgical interventions applied to osteoporotic bone augmentation, when the risk of bone fracture becomes imminent. Specifically in this proposal, we demonstrate the feasibility of bone augmentation by developing a surgical system for femur augmentation
Role: Co-investigator (PI is M. Armand)

Title: Active Multi-Spectral Illumination for Video Microscopy and Endoscopy
Dates: 9/1/2008-6/30/2010
Grantor: Equinox Corp.
Award amount: $149,998
Summary: This is a small project to explore active illumination schemes for endoscopy and microscopy
Role: Principal investigator

Title: Initiative for Innovations in Interventional Medicine
Dates: 08/01/07-07/31/10
Grantor: Johns Hopkins University / Fraunhofer Gesellschaft
Award amount: $891,000 for JHU portion

Summary: This is a jointly funded collaborative project between Johns Hopkins University and Fraunhofer Institute to develop technology for computer-assisted endoscopic surgery. The funds for the JHU investigators come from JHU internal funds.
Role: Co-investigator (PI is E. McVeigh)

Title: **Ultrasound Guidance for a Laparoscopic Surgical Robot**
Dates: 8/15/06-7/31/2010
Grantor: National Institutes of Health
Award number: Phase II STTR 2 R42 RR019159
Award amount: $330,075 direct spending; $386,433 total
Summary: The goal of this Phase II STTR with Intuitive Surgical is development of a "third hand" laparoscopic ultrasound capability for the daVinci surgical robot
Role: Principal investigator

Title: **Engineering Research Center for Computer-Integrated Surgical Systems and Technology (CISST ERC).**
Dates: 9/1/97-12/31/2009
Grantor: National Science Foundation
Award Number: EEC9731478
Amount: $30,189,932
Summary: This was the core "seed money" grant for the CISST ERC. The CISST ERC is a multi-institutional, multidisciplinary center whose focus is of basic science, computer-based technology, and engineered systems working cooperatively with surgeons to significantly change the way surgical procedures are carried out in the 21st century. Significant research focuses include modeling and analysis for treatment planning and control, robotics and human interfaces and systems for minimally-invasive, image-guided percutaneous therapy and microsurgery. Although the NSF grant is now "spent out", the Center continues.
Role: Principal Investigator and ERC Director. In addition to my duties as ERC Director, I also participate in a variety of ERC research in medical robotics, image registration, modeling, and systems.

Title: **Surgical Assistant Workstation for Telesurgical Robotics Research**
Dates: 9/1/97-12/31/2009
Grantor: National Science Foundation
Award Number: Supplement to EEC9731478
Amount: $529,277direct spending; $691,454 total
Summary: This is a collaborative project between the NSF Engineering Research Center for Computer-Integrated Surgical Systems and Technology (CISST ERC) and Intuitive Surgical, Inc. (ISI) to develop an open-source software environment for medical robotics and computer-integrated surgery research.
Role: Principal Investigator

Title: **E-science Meets Radiation Oncology: Information-based closed loop interventional medicine**
Dates: 4/1/07-12/31/2009
Grantor: Maritz Fund
Award amount: $232,540
Summary: This project explores the statistical relationship between anatomic shape and treatment planning in radiation oncology
Role: Principal investigator

Title: **Winter School on Medical Robotics and Computer-Integrated Interventional Systems (MRCIIS)**
Dates: 2008-2009
Grantor: IEEE Robotics and Automation Society

Award amount: $25,000
Summary: This was a small grant from IEEE RAS to help support the Winter School in January 2009. This was an intensive 1 week short course for post-graduate and post-doctoral students on medical obotics and computer-integrated interventional medicine. The course includes tutorial lectures and research talks by internationally recognized faculty, lab tours & demonstrations in our new facilities in the Computational Sciences and Engineering Building on the Johns Hopkins Homewood Campus, and a compressed version of Johns Hopkins' unique Surgery for Engineers course.
Role: Principal investigator

Title: Dexterous, Compact Telesurgical Robot for Throat & Airways
Dates: 03/01/05-02/28/09
Grantor: National Institutes of Health
Award number: NIH 1 R21 EB0045457-01
Award amount: $274,999 direct; $440,500 total
Summary: The goal of this project was development and initial evaluation on phantoms of a very compact, high-dexterity telesurgical robot system suitable for minimally invasive surgery of the throat & airways.
Role: Principal investigator

Title: Direct Video-CT Registration for High-Precision Surgical Navigation
Dates: 04/01/06 – 03/31/09
Grantor: National Institutes of Health
Award number: 1R21EB005201 - 01A1
Award amount: $125,000
Summary: The goal of this project is to demonstrate that direct registration of endoscopic video to pre-operative CT is a viable route to increasing the precision and usefulness of current surgical navigation systems. These results will set the stage for developing new approaches to high precision intra-operative navigation and visualization in anterior skull surgery
Role: Co-investigator (PI is G. Hager)

Title: Modeling Synthesis and Analysis of Human Machine Collaborative Systems
Dates: 10/1/2002-9/30/2008
Grantor: National Science Foundation
Award number: IIS0205318 (medium ITR)
Award amount: $1,100,000
Summary: Creating complete systems for different types of puncture tasks, examining and exploiting the commonalities of those tasks for single handed augmentation.
Role: Co-Investigator (PI is G. Hager)

Title: Prior Knowledge in 3D Reconstruction from 2D X-Rays
Dates: 08/01/04-07/31/08
Grantor: NIH
Award number: NIH1-R21 EB003616-01
Award amount: $375,000 direct; $589,952 total
Summary: This project will develop and validate novel algorithms for 3D CT-like reconstruction of bone images from mobile c-arm images. The novelty of the proposed methods will be their exploitation of prior knowledge in the form of prior CT scans when available and a statistical atlas when CT is not available. We use orthopaedic surgery as a focusing application.
Role: Co-Investigator (PI was Jerry Prince)

Title: Computer-assisted Hip Osteotomy Surgery with Real-Time Biomechanical Guidance
Dates: 10/01/03-08/31/05
Grantor: National Institutes of Health
Award number: 1R21EB002881-01

Award amount: $75,672 (for JHU Homewood part)
Summary: The goal of this project is integration of preoperative and on-line biomechanical analysis for periacetabular osteotomies with a CT based surgical navigation system, together with a patient study of the resulting system.
Role: Co-investigator

Title: **Ultrasound Assistant for a Laparoscopic Surgical Robot**
Dates: 11/11/04-07/31/05
Grantor: NIH
Award number: R41 RR019159
Award Amount: $59,999
Summary: The goal of the Phase I STTR project (with Intuitive Surgical Systems) is development of a "third hand" laparoscopic ultrasound capability for the daVinci surgical robot.
Role: Principal investigator

Title: **Robot-assisted Needle Placement in Ultrasound-guided Liver Ablation**
Dates: 09/30/03-09/30/04
Grantor: National Institutes of Health
Award number: 1R41CA103468
Summary: This is a Phase I STTR with Burdette Medical Systems and JHU Medical School to develop an ultrasound-guided robotic system for percutaneous RF ablation of liver tumors.

Title: **Research on Applications of Localizer Technology**.
Dates: 6/2002-6/2004
Grantor: Northern Digital, Inc.
Amount: Approx $150,000 total
Summary: Industrially sponsored research aimed at characterization and novel applications of 3D navigational systems.
Role: Principal Investigator

Title: **Scale-Invariant Skill Augmentation for Cooperative Human-Machine Micromanipulation Systems**
Dates: 7/1/2001-6/30/2004
Grantor: National Science Foundation
Award number: IIS0099770
Award Amount: $380,000
Summary: Human-machine cooperation for skilled manipulation tasks. The research is on basic technology and techniques, using microsurgical tasks as a focus.
Role: Co-Investigator

Title: **Cooperative Steady Hand Augmentation of Human Skill in Micromanipulation Tasks**
Dates: 8/30/1998-8/31/2003
Grantor: National Science Foundation
Award number: IIS 9801684
Award amount: $242,737
Summary: Robotic systems and novel cooperative control methods for extending human abilities to perform extremely precise manipulation tasks, using applications in microsurgery and otology as focus. Results included demonstration of a novel "steady hand" robot system and its application in retinal vein cannulation, stapedotomy, and access to the cochlea of the inner ear. Note: This project is the predecessor to IIS099770, and is on continuation of funding to permit wrapping up of results.
Role: Principal Investigator

Title: **Augmented Micro-Manipulation System**
Dates: 7/1/2002-12/31/2002
Grantor: Foster Miller

Award number: SUB100078 (on NSF SBIR to Foster-Miller, Inc.)
Award amount: $30,000
Summary: The goal of this Phase I SBIR is feasibility demonstration and preliminary evaluation of the use of steady-hand robots for cell surgery
Role: Principal Investigator for JHU component

Title: **X-ray registration for spine surgery**
Dates: Approx. April 2001-September 2001
Grantor: Orthosoft
Award number: N/A
Award amount: Approx $21,000
Summary: This was a short-lived cooperative project with Orthosoft, Inc. to investigate new methods for x-ray registration in spine surgery.
Role: Principal Investigator for JHU component

Title: **CISE Research Infrastructure: A Networked Computing Environment for The Manipulation and Visualization of Geometric Data**
Dates: 8/14/1997-7/31/2003
Grantor: National Science Foundation
Award Number: EIA-9703080
Award Amount: $1,226,381
Summary: This was a shared research infrastructure grant that provided computing equipment for a variety of research projects involving several Johns Hopkins Computer Science faculty members
Role: Co-investigator

Title: **Image Guided Percutaneous Robotic Assisted Therapy**
Dates: 7/1/1995-6/30/1998
Grantor: National Science Foundation
Award number: BES9520501
Award amount: $762,425
Summary: Systems and technology research on robotically-assisted delivery of percutaneous therapy under CT and x-ray guidance, using liver brachytherapy as main focusing application. This project led to development of much of the infrastructure that was later incorporated into percutaneous therapy research within the ERC
Role: Co-Investigator

Title: **Instrumentation for Computer Science & Engineering Research in Image Segmentation, Registration, Modeling and Interactive Model-Based Task Optimization**
Dates: 2/15/1996-1/31/1999
Grantor: National Science Foundation
Award number: CDA-9529509
Award amount: $113,207
Summary: Shared instrumentation grant involving 2 Johns Hopkins CS faculty members used to buy computers and other equipment for research on image processing anc computer-assisted surgery
Role: Principal Investigator

Title: **Robotic Revision Hip Replacement Surgery**
Grantor: Integrated Surgical Systems/National Institute of Science and Technology
Dates: 10/95-4/98
Award number: NIST ATP Cooperative Agreement No. 94-01-0228.
Award amount: $230,239
Summary: Development of x-ray registration and guidance methods for robotically-assisted revision hip replacement. This was the Johns Hopkins component of a $4M NIST ATP involving IBM, Integrated Surgical Systems and (after I moved to JHU), Johns Hopkins
Role: Principal Investigator for JHU component; earlier was principal investigator for IBM

Title: **Workshop on Surgical Robotics**

Dates: 1993
Grantor: National Science Foundation
Award Number: 9222082
Award amount: $30,000
Summary: This was the first NSF-sponsored planning workshop on medical robotics and computer-assisted surgery
Role: Principal investigator and workshop co-chairman (with George Bekey)

WORK HISTORY (with summaries)

1995-now Johns Hopkins Univ. Professor of Computer Science, with joint appointments in Mechanical Engineering, Radiology, Surgery and Otolaryngology Head-and-Neck Surgery

Director of Laboratory for Computational Sensing and Robotics. Director of [Graduated] NSF Engineering Research Center on Computer-Integrated Surgical Systems and Technology. Current research interests include: computer-integrated planning and robotic delivery of optimized patterns of localized therapy; steady-hand augmentation of microsurgery and endoscopic surgery; image-guided orthopaedic surgery; medical imaging, modeling, and registration; and human-machine systems.

1990-1995 IBM Research Manager of Computer Assisted Surgery Group

Technical direction and leadership for research group (5 PhD's, 1 Engineer, 1 coop student) in medical robotics and computer assisted surgery. Specific activities included orthopaedics, craniofacial surgery, image guided telerobotic systems for minimally invasive surgery, and image-based modeling and analysis. Set strategy and research agenda, contributed key technical ideas, participated/led in implementations and negotiated relations with outside organizations. Led successful effort to secure $2M NIST ATP support for a joint IBM/Integrated Surgical Systems project to develop system for revision hip replacement surgery, and subsequently was principal investigator for IBM's part of the project..

1989-1990 IBM Research Research Staff Member/Project Leader

Developed "Robodoc" a robotic system for precise orthopaedic surgery, and transferred it to clinical collaborators at the University of California at Davis and, subsequently, to a startup company (Integrated Surgical Systems, Inc..) for commercial development. This system is now marketed in Europe and is pending FDA approval in the US. Also, established a broader research program on medical robotics and human-machine augmentation and initiated joint work on craniofacial surgery with NYU.

1987-1988 IBM Research Manager of Automation Technology

Department: Technical and administrative leadership for 22 researchers in robotics and vision;
liasons with key IBM manufacturing sites; continued technical research; and external professional activities with NSF, IEEE, etc. Department research themes included coarse-fine manipulation,
endpoint sensing and control, computational architectures and programming environments for robotics and vision, massively parallel computation, model-based planning, and advanced applications.

1982-1987 IBM Research Manager of Robot Systems and Technology

Established 3-person research group in 1982 and grew it to a 15-person, three group department covering a broad spectrum of robotics research topics (see above). Activities included coarse-fine manipulation and endpoint sensing concepts, a multi-processor computational architecture for integrated sensing and control, and advanced applications for use inside IBM. Collaborated on AML/X extension to AML.

1982 MIT AI Lab Visiting Scientist

Co-developed "LMT" paradigm for automatic synthesis of manipulator fine motion strategies from analysis of configuration space. This paradigm has led to three generations of PhD theses on motion planning at several universities.

1980-1982 IBM Research Research Staff Member

Led effort that extended the RS/1 AML system to incorporate concurrent multiple arm control, vision, and a number of other features for research and advanced applications. Collaborated in development of robot for IBM clean rooms, led implementation of distributed controller architecture, and continued to advise IBM robot product group.

1978-1979 IBM Boca Raton Advisory Engineer

Product Architect for the IBM RS/1 and 7565 robot systems and product version of AML language.

1976-1977 IBM Research Research Staff Member

Principal designer and implementor of AML robot language. Other robotics research including bounded deviation straight line manipulator trajectories, application programming and sensor-based calibration techniques, and collaboration on a very sophisticated two-armed robot for testing IBM mainframes.

1970-1976 Stanford University Research Assistant

Dissertation research on sensor-based fine motion synthesis; co-development of AL robot language and POINTY teaching system; extension of SAIL programming language.

1968-1970 Johns Hopkins Univ. Research Assistant

Implementation of efficient codes for mathematical programming algorithms (mostly travelling salesman, multi-commodity network flow problems).