BIOGRAPHICAL SKETCH

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NAME: Daniel, Bruce L.

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POSITION TITLE: Professor of Radiology and, by courtesy, of Bioengineering

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Williams College, Williamstown, MA	B.A.	06/1985	Physics
Harvard Medical School, Boston, MA	M.D.	06/1990	Medicine
Mount Sinai Medical Center, NY, NY	Internship	06/1991	Internal Medicine
University of Michigan, Ann Arbor, MI	Residency	06/1995	Diagnostic Radiology
Stanford University, Stanford, CA	NCI Fellowship	06/1997	Body/Cancer Imaging

A. Personal Statement

Clinically, I have been involved in breast MRI since 1995. I direct the breast MRI service at Stanford which performs over 1200 exams per year, overseeing all protocols. I interpret breast MRI exams and perform MRI-guided breast biopsies and localizations every week. I am also a member of the body MRI service at Stanford which performs a wide range of abdominal and pelvic scans, especially for oncology, and I have also performed numerous MR-guided soft tissue biopsies including trans-perineal prostate biopsies, as well as in other abdominal and pelvic soft tissues. I am an active member of Stanford's NIH NCI-designated cancer center and member of the breast, OB/GYN and genitourinary tumor boards, I collaborate frequently with oncologic surgeons, pathologists, oncologists, and radiation therapists. This experience will enable me to oversee the collaborations with clinicians, and direct the clinical research portions of the proposal.

My research program focuses on translation of new techniques for cancer imaging, and image-guided interventions. I've been PI on several RO1 and R21 grants on breast cancer MR imaging and I am currently the Body project leader on Stanford's multiple project research grant from GE Healthcare that supports development of new MR imaging techniques for breast, among other applications. As PI of a previous Whitaker Foundation grant, an R21, and an R01 grant on MRI-guided prostate cryosurgery, I gained substantial experience in the evaluation of new image-guided minimally invasive therapies. More recently I have started, and co-direct, IMMERS.stanford.edu, an incubator which aims to improve patient health with mixed-reality applications, including augmented-reality MRI-guided breast conserving surgery.

B. Positions and Honors

Positions and Employment

1990-1991 Intern, Internal Medicine, Mount Sinai Medical Center, New York, NY.
1991-1994 Resident, Department of Radiology, University of Michigan Hospitals, Ann Arbor, MI.
1994-1995 Chief Resident, Department of Radiology, University of Michigan Hospitals, Ann Arbor
1995-1997 National Cancer Institute Body Imaging Fellowship, Department of Radiology, Stanford University, Stanford, CA.
1997-2005 Assistant Professor of Radiology, Stanford University, Stanford, CA
2005-2011 Associate Professor of Radiology, with Tenure, Stanford University, Stanford, CA
2011-present Professor of Radiology, with Tenure, Stanford University, Stanford, CA
2006-present Director of Breast MRI Service, Stanford University, Stanford, CA
2018-pesent Co-Director of IMMERS, the Incubator for Medical Mixed and Extended Reality at Stanford

Honors and Awards

1995-97	Recipient of National Cancer Institute Cancer Imaging Training Grant Fellowship, Stanford University Department of Radiology.
1998	Gary Becker Award for Outstanding Interventional Radiology Paper [Contributing Author].
2000	Moncada Award for an Outstanding Scientific Paper on Cross Sectional Imaging, Society of Computed Body Tomography and Magnetic Resonance [**First Author**].
2001	Finalist, Young Investigator Competition, Association for Advancement of Medical Instrumentation [principal advisor to first author Janaka Wansapura, PhD].
2002	Elected Fellow of Society of Computed Body Tomography and Magnetic Resonance
2008	Lauterber Award in MR. Society of Computed Body Tomography and Magnetic Resonance. [Contributing Author]
2010	Finalist, W. S. Moore Award in clinical science, International Society for Magnetic Resonance in Medicine, Stockholm, Sweden. [Mentor to finalist, Rebecca Rakow-Penner, MD PhD]
2012	Elected to Council of Distinguished Investigators, Academy of Radiology Research.
2015	Merit Award, Summa Cum Laude. International Society for Magnetic Resonance in Medicine. June 2015. "Two-Dimensional Multiband Diffusion Weighted Imaging." [Contributing author. First Author: Valentina Taviani].
2016	Elected Fellow, American Institute for Medical and Biological Engineering.
2017	Merit Award, Magna Cum Laude, *and* 2nd place Best Interventional Study Group Presentation Award. "MR-Guided Mixed-Reality for Surgical Planning: Set-Up and Perceptual Accuracy." 25th ISMRM, April 22-27, 2017, Honolulu, HI. [Senior Author. First Author: Subashini Srinivasan].
2017	2nd Place Best Interventional Study Group Poster Award. "Artifact-Reduced Imaging of Biopsy Needles with 2D Multi-Spectral Imaging." 25th ISMRM, April 22-27, 2017, Honolulu, HI. [Second Author. First Author: Hans Weber].
2017	Finalist, Best Student Presentation. "Haptic feedback of membrane puncture with an MR-compatible instrumented needle and electroactive polymer display." IEEE World Haptics Conference, Munich, Germany, June 6-7, 2017. [Contributing author. First Author: Jung Hwa Bae].
2017	Finalist, Best Medical Robotics Paper. "A Rolling-Diaphragm Hydrostatic Transmission for Remote MR-Guided Needle Insertion". IEEE ICRA May 29-June 3, 2017, Singapore. [Contributing Author. First Author: Natalie Burkhard].
2018	Elected Fellow, Society of Breast MRI, First Inaugural Meeting, May, 2018, Washington DC.

C. Contributions to Science

For a complete list of publicly accessible papers, please see my NCBI bibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/bruce.daniel.1/bibliography/48067877/public/?sort=date&direction=ascending

I. Techniques for dynamic contrast-enhanced MRI. Traditionally breast MRI was performed with either limited spatial coverage, limited spatial resolution, or limited temporal resolution because of the speed with which MRI scanners could obtain data points. Our group was among the first to pioneer the use of faster non-Cartesian methods [1]. We subsequently extended this technique to 3D, and then bilateral methods. Recently we reported a new view-shared & parallel imaging accelerated method that provides dynamic images with extremely high spatial and temporal resolution called DISCO that was featured on the cover of JMRI [2]. These techniques have enabled many clinical reports and, recently, we have reported advanced methods to combine DISCO with compressed sensing called "complementary Poisson disk sampling" with application to breast and other cancers [3].

1. **Daniel BL**, Yen YF, Glover GH, Ikeda DM, Birdwell RL, Sawyer-Glover AM, Black JW, Plevritis SK, Jeffrey SS, Herfkens RJ. Breast disease: dynamic spiral MR imaging. Radiology. 1998 Nov;209(2):499-509.
2. Saranathan M, Rettmann DW, Hargreaves BA, Lipson JA, **Daniel BL**. Variable spatiotemporal resolution three-dimensional dixon sequence for rapid dynamic contrast-enhanced breast MRI. J Magn Reson Imaging. 2014 Dec;40(6):1392-9. PMCID: PMC4019731.

3. Levine E, **Daniel BL**, Vasanawala S, Hargreaves B, Saranathan M. 3D Cartesian MRI with compressed sensing and variable view sharing using complementary poisson-disc sampling. Magn Reson Med. 2016 Apr 21. In press. [Epub ahead of print] PMID: 27097596. PMCID: PMC5074926.

II. Techniques for non-contrast cancer MRI: While Gadolinium-based contrast agents are the most sensitive method to detect cancer with MRI, other non-contrast MRI methods are important for two reasons: One, they may aid in the characterization of breast disease, and two, they may one day become sensitive enough for tumor detection to replace contrast-enhanced MRI. The principal non-contrast technique is T2-weighted imaging. We recently reported the use of 3D T2 FSE imaging for higher resolution breast images than are typically obtained with multi-slice 2D sequences [1]. Diffusion-weighted imaging is also increasingly important as a means of imaging cancer without contrast material. We recently reported that DWI reveals morphologic features in addition to restricted diffusion that are a specific sign of breast cancer [2]. We also showed that small field-of-view image can dramatically improve the image quality and resolution and diagnostic accuracy of DWI [3]. We also recently reported a 3D steady-state method of even higher quality diffusion-weighted images, called "Double Echo Steady State" [4]. Finally, we recently submitted work reporting that synthetic high B-value imaging adds sensitivity for prostate cancer, at the expense of specificity, with no net overall increase in accuracy.

1. Moran CJ, Hargreaves BA, Saranathan M, Lipson JA, Kao J, Ikeda DM, **Daniel BL**. 3D T2-weighted spin echo imaging in the breast. J Magn Reson Imaging. 2014. Feb;39(2):332-8. PMID: 23596017; PMCID: PMC3735677.
2. Kang BJ, Lipson JA, Planey KR, Zackrisson S, Ikeda DM, Kao J, Pal S, Moran CJ, **Daniel BL**. Rim sign in breast lesions on diffusion-weighted magnetic resonance imaging: Diagnostic accuracy and clinical usefulness. J Magn Reson Imaging. 2015 Mar;41(3):616-23.
3. Barentsz MW, Taviani V, Chang JM, Ikeda DM, Miyake KK, Banerjee S, van den Bosch MA, Hargreaves BA, **Daniel BL**. Assessment of tumor morphology on diffusion-weighted (DWI) breast MRI: Diagnostic value of reduced field of view DWI. JMRI. 2015; 42(6):1656-65. PMCID: PMC4619182.
4. Granlund KL, Staroswiecki E, Alley MT, **Daniel BL**, Hargreaves BA. High-resolution, three-dimensional diffusion-weighted breast imaging using DESS. Magn Reson Imaging. 2014, May;32(4):330-41. PMCID: PMC4041802.

III. Techniques for MR-guided ablations and interventions in the body: Ever since completing my cancer imaging fellowship, I have investigated novel methods for MRI-guided interventions. This includes some breast applications, such as the first report of MRI-guided radio-frequency ablation in the breast as well as non-breast applications such MRI-guided TIPS using the hybrid X-Ray/MR system developed at Stanford. We have also lead a long-standing project investigating ultra-short TE MRI as a method of mapping temperatures in the prostate during cryosurgery [1.] My group has also contributed a number of papers to the development of minimally invasive MR-guided breast biopsy including clinical reports [2], and biopsy system development [3].

1. Wansapura J, **Daniel BL**, Vigen K, Butts, K. In Vivo MR thermometry of frozen tissue using R2* and signal intensity. Acad Radiol. 2005 Sep;12(9):1080-4.
2. van den Bosch MA, **Daniel BL**, Pal S, Nowels KW, Birdwell RL, Jeffrey SS, Ikeda DM. MRI-guided needle localization of suspicious breast lesions: results of a freehand technique. Eur Radiol. 2006 Aug;16(8):1811-7.
3. **Daniel BL**, Freeman LJ, Pyzoha JM, McCoy TD, Birdwell RL, Bouley DM, Movius B, Hibner JA. An MRI-compatible semi-automated vacuum assisted breast biopsy system: initial feasibility study. J Magn Reson Imaging. 2005 May;21(5):637-44.

IV. MR compatible robotics including haptics and remote manipulation: Although most of our early work leveraged our open scanner, future MR-guided interventions will be performed in closed bore scanners. To address this, we have developed a number of MRI-compatible remote manipulation strategies, including a passively coupled parallel robot delta mechanism [1] and MRI-compatible steerable needles [2]. We have developed micromachined needles with MRI-compatible sensors that report force [3] and shape [4] changes in the needle every few milliseconds.

1. Elayaperumal S, Cutkosky MR, Renaud P, **Daniel BL**. A Passive Parallel Master-Slave Mechanism for Magnetic Resonance Imaging-Guided Interventions. J Med Device. 2015 Mar;9(1):0110081-1100811. PMCID: PMC4245788.

2. Ryu S, Fan Quek Z, Koh J-S, Renaud P, Black RJ, Moslehi B, **Daniel B**L, Cho K-J and Cutkosky MR, Design of an Optically Controlled MR-compatible Active Needle, IEEE Transactions on Robotics 2015 31(1) 1-11. PMCID: PMC4620588.
3. Elayaperumal, S, Bae JH, **Daniel BL,** and Cutkosky MR, Detection of Membrane Puncture with Haptic Feedback using a Tip-Force Sensing Needle, IROS, 2014, 3975 - 3981,14-18 Sept. 2014. doi:10.1109/IROS.2014.6943121 PMCID: PMC4620049.
4. Elayaperumal S, Plata JC, Holbrook AB, Park YL, Pauly KB, **Daniel BL**, Cutkosky MR. Autonomous real-time interventional scan plane control with a 3-D shape-sensing needle. IEEE Trans Med Imaging. 2014 Nov;33(11):2128-39. PMCID: PMC5026644.

V. Medical Mixed-Reality. My earliest work included 3D pre-operative visualization [1] for surgeons. Most recently I started a new initiative to bring MRI fully back to the OR through mixed-reality. We convinced Microsoft to put a "Showcase" team on the project. We received several seed grants (CBCRP and Bio-X, below) and have published multiple meeting abstracts [2,3]. In addition to breast interventions, our group is now working on mixed-reality guided neurological procedures, orthopedic procedures and thoracic surgery.

1. **Daniel BL**, Jeffrey SS, Birdwell RL, Ikeda DM, Sawyer-Glover AM, Herfkens RJ. Three-dimensional shaded-surface rendering of MR images of the breast: technique, applications, and impact on surgical management of breast disease. Radiographics. 1998 Mar-Apr;18(2):483-96Lin M, Bae J, Srinivasan S, Perkins S, Leuze S, Hargreaves B, Cutkosky M, **Daniel B**. MRI-guided Needle Biopsy using Augmented Reality. Proc. of the 25th Annual Meeting of ISMRM, Honolulu 2017.
2. Perkins S, Shi X, Weber H, **Daniel B**, Hargreaves B.A. MR Imaging of Magnetic Ink Patterns via Off-Resonance Sensitivity. Proceedings of the 25th Annual Meeting of ISMRM, Honolulu 2017.
3. Srinivasan S, Wheeler A, Hargreaves B, **Daniel B**. MR-guided mixed-reality for surgical planning: Set-up and perceptual accuracy. Proceedings of the 25th Annual Meeting of ISMRM, Honolulu 2017.
4. Perkins SL, Lin MA, Srinivasan S, Wheeler AJ, Hargreaves BA, **Daniel BL**. A Mixed-Reality System for Breast Surgical Planning. *Proceedings of the 2017 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct), pages 269-274.* DOI 10.1109/ISMAR-Adjunct.2017.92

Ongoing Research Support

R01CA218204 Dahl/Daniel/DeMartini (MPI) 08/01/2017-07/31/2022
NIH
Automated Volumetric Molecular Ultrasound for Breast Cancer Imaging
Overall Goal: To develop, optimize, and clinically test a new operator-independent whole-breast ultrasound imaging system based on a commercially available and widely used automated human breast volume scanner (ABVS), supporting molecular imaging to be used for early breast cancer detection and improved characterization of focal breast lesions in the clinic.
Role: Co-PI

A-105 Hargreaves (PI) 04/1/2008-03/31/2020
General Electric Medical Systems
Stanford Tiger Team Projects
Overall Goal: Improving image quality and developing new techniques for MRI applications in the abdomen and pelvis.
Role: Body Project Team Lead

IIS 1615891 Cutkosky (PI) 8/1/16-7/31/19
NSF/Northeastern University
CHS: Small: Collaborative: Teleoperation with passive, transparent force feedback for MR-guided interventions.
Overall Goal: The purpose of this grant is to develop novel fluid-drive, robotic-inspired, teleoperation systems for robust use in the MRI environment, as potential solutions for remote needle insertion and other topics.
Role: Co-PI for Stanford Collaboration (Sub Contract).

Blue Sky (SPO#131206) Daniel (PI) 9/1/2017-9/30/2019
General Electric Healthcare
Augmented Reality Visualization of Medical Imaging Data.

Overall Goal: To determine if 3D Augmented Reality Interactive Visualization facilitates surgical understanding of vascular anatomy among potential kidney donors.
Role: PI

T32CA009695-25 Daniel (MPI) 3/1/13-2/28/19
NIH / NCI
Stanford Cancer Imaging Training (SCIT) Program
Overall Goal: This grant supports post-docs and physicians –in-training for a 2-year research fellowship with a mentor at Stanford, to pursue a core curriculum of cancer imaging courses, and a project in cancer imaging.
Role: Principal Investigator (MPI)

Bio-X Daniel (PI) 10/1/16-9/30/19
Stanford University
Technologies for Mixed-Reality Breast Surgery
Overall Goal: To create patient-specific mechanical models of the breast that can predict changes in internal tissue configuration based on changes in skin markings; to validate their accuracy; and to integrate them into a mixed reality system to improve surgical outcomes.
Role: Principal Investigator

SCI-WCCIA Daniel (PI) 9/1/2018-8/31/2019
Stanford University
A Novel Approach to Breast Conservation Surgery: Mixed-Reality Tumor Visualization and Localization.
Overall Goal: To develop and test mixed-reality technologies to track and display the location and extent of the breast cancer tumor to the surgeon, in the operating room.
Role: PI

Completed Research Support (selected grants)

P01-CA159992 Butts-Pauly (PI) 9/22/11-8/31/17
NIH
Magnetic resonance Imaging Guided Cancer Interventions
Comprised of 5 projects, including HIFU of soft tissue tumors, MRI-Guided Management of Prostate Disease, MR-Guided Thermal Therapy of Retroperitoneal Tumors, MRI Methods for Guiding Focused Ultrasound in the Brain and MR-guided RF Ablation, plus an engineering core, and an *in vivo* study support core that assists all of the projects.
Roles: Project 2 (Prostate) Leader; Administrative core member; Software core leader.

R01 EB009055-01 Daniel (MPI) 1/1/13-12/31/17
NIH
High Resolution Whole Breast MRI at 3.0T
This research will develop much higher resolution breast MRI hardware and software, allowing better classification of small lesions to prevent unnecessary biopsy and detect cancer earlier.
Role: Principal Investigator (MPI)

IDEA Award 22IB-0006 Daniel (PI) 9/1/16-2/28/18
California Breast Cancer Research Program
Technologies for Augmented Reality Breast Surgery
This project is developing a head-mounted mixed reality display to render breast MRI images within a patient's breast, and to test its accuracy as a surgical planning tool among a cohort of women with palpable tumors.
Role: Principal Investigator

Sponsored Projects Gold (PI) 4/1/16-3/31/18
General Electric Healthcare
Advanced Body MRI Applications
These projects aim to advance vascular and body MRI including abdominal imaging, motion correction, liver and prostate imaging, through collaboration between GE researchers, MRI scientists and clinical radiologists.
Role: Body MRI Project PI