BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Pauly, John Mark

eRA COMMONS USER NAME: pauly.john

POSITION TITLE: Professor of Electrical Engineering

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE	Completion Date	FIELD OF STUDY
Iowa State University, Ames, IA	B.S.	1979	Electrical Engineering
Carnegie-Mellon University, Pittsburgh, PA	M.S.	1981	Electrical Engineering
Stanford University, Stanford CA	Ph.D.	1990	Electrical Engineering

A. **Personal Statement**

I have extensive experience in the development of MR Imaging technology, including RF pulse design, pulse sequence design, and image reconstruction algorithms. I am Co-Director of the Magnetic Resonance Systems Research Laboratory (MRSRL) which is devoted to MR instrumentation research. We have NIH supported projects in device safety in MRI, in developing wireless flexible receive arrays, and in MR guided minimally invasive RF ablation. Other collaborations include pulse sequence development for hyperpolarized 13C MR spectroscopic imaging, the development of SSFP fMRI, and the development of simultaneous multislice RF pulses and reconstruction techniques.

B. Positions and Honors

1979-1980 Nichols Research Corporation: Analysis and design of IR sensors for ballistic missile defense.

1980-1981 Carnegie-Mellon University: MS student in EE
1981-1983 MIT Lincoln Laboratory: Radar systems analysis and radar signal processing.
1983-1984 Elscint Inc.: R&D for ultrasound sector scanner and pulse Doppler systems.
1984-1990 Stanford University: Ph.D. student in Electrical Engineering.
Thesis title: “New Approaches to Selective Excitation for Magnetic Resonance Imaging.”
1990- 2001 Research Associate in Electrical Engineering working on magnetic resonance imaging.
2001- 2008 Associate Professor, Department of Electrical Engineering, Stanford University.
2008- Professor, Department of Electrical Engineering, Stanford University.

Fellow, American Institute of Medical and Biological Engineering (AIMBE, 2014)
Gold Medal, International Society of Magnetic Resonance in Medicine (2012)
Fellow, International Society of Magnetic in Medicine (2005)
Associate Editor*, IEEE Transactions on Medical Imaging* (2004-Present)
Associate Editor, *Magnetic Resonance in Medicine* (2010-2014)
Holder of 60 U.S. Patents
US Patent Agent, registration number 43850
FCC Extra Class Amateur Radio License (AG6WH)
Author of 162 Refereed Journal Publications
Chartered Member, NIH Biomedical Technology and Surgical Systems (BTSS) study section (2012-2016)

C. Contributions to Science

1. **Selective Excitation in MRI** My earliest contributions are in RF pulse design for selective excitation in MRI. This includes the k-space formulation of selective excitation (a), which led to multidimentional excitation pulses, including spectral spatial pulses (b). Other contributions are in the Shinnar-Le Roux algorithm for designing large tip-angle 1D pulses (c). These methods are widely used in MRI and in MR Spectrosopic Imaging (MRSI) (d).
    a. "A k-space analysis of small-tip-angle excitation" J Pauly, D Nishimura, A Macovski, *J. Magn Reson* 213 (2), 544-557
    b. "Simultaneous spatial and spectral selective excitation" CH Meyer, JM Pauly, A Macovski, DG Nishimura, Magn Reson Med 15 (2), 287-304
    c. "Parameter relations for the Shinnar-Le Roux selective excitation pulse design algorithm." Pauly J, Le Roux P, Nishimura D, Macovski A. *IEEE Trans Med Imaging*. 1991;10(1):53-65. PMID: 18222800
    d. "Multiband excitation pulses for hyperpolarized 13C dynamic chemical-shift imaging." Larson PE, Kerr AB, Chen AP, Lustig MS, Zierhut ML, Hu S, Cunningham CH, Pauly JM, Kurhanewicz J, Vigneron DB*. J Magn Reson*. 2008 Sep;194(1):121-7. PMID: 18619875
2. **Imaging Short T2 species** The k-space formulation of selective excitation led to slice selective pulses for imaging short T2 species, and methods for imaging with positive short T2 contrast. This has been applied to imaging lung (a), musculoskeletal (b), and frozen tissue (c), and remains an active area of research with the recent advent of zero echo time (ZTE) imaging methods. A major effort has been the development of methods to produce positive short T2 contrast (d).
    a. "Lung parenchyma: projection reconstruction MR imaging." Bergin CJ, Pauly JM, Macovski A. Radiology. 1991 Jun;179(3):777-81. PMID: 2027991
    b. "MR spectroscopic imaging of collagen: tendons and knee menisci." Gold GE, Pauly JM, Macovski A, Herfkens RJ. *Magn Reson Med.* 1995 Nov;34(5):647-54. PMID: 8544684
    c. "Temperature quantitation and mapping of frozen tissue." Butts K, Sinclair J, Daniel BL, Wansapura J, Pauly JM. *J Magn Reson Imaging*. 2001 Jan;13(1):99-104. PMID: 11169810
    d. "Designing long-T2 suppression pulses for ultrashort echo time imaging." Larson PE, Gurney PT, Nayak K, Gold GE, Pauly JM, Nishimura DG. *Magn Reson Med*. 2006 Jul;56(1):94-103. PMID: 16724304
3. **Real-time imaging** As a research associate in the 1990's I led the effort at Stanford in the development of real-time interactive MRI (a). The primary applications were cardiac imaging (a-c) and MR guided interventions (d, and below). For cardiac imaging this involved developing MR equivalents of echocardiography techniques such as color flow (c), and pulsed Dopper (b). This work is the basis for a commercial company HeartVista, that sells a system that implements these techniques on commercial GE MRI systems.
    a. "Real-time interactive MRI on a conventional scanner." Kerr AB, Pauly JM, Hu BS, Li KC, Hardy CJ, Meyer CH, Macovski A, Nishimura DG. *Magn Reson Med.* 1997 Sep;38(3):355-67. PMID: 9339436
    b. "Localized real-time velocity spectra determination." Hu BS, Pauly JM, Nishimura DG. *Magn Reson Med*. 1993 Sep;30(3):393-8. PMID: 8412614
    c. "Real-time color flow MRI." Nayak KS, Pauly JM, Kerr AB, Hu BS, Nishimura DG. *Magn Reson Med*. 2000 Feb;43(2):251-8.
    d. "High-resolution real-time spiral MRI for guiding vascular interventions in a rabbit model at 1.5T." Terashima M, Hyon M, de la Pena-Almaguer E, Yang PC, Hu BS, Nayak KS, Pauly JM, McConnell MV*. J Magn Reson Imaging.* 2005 Nov;22(5):687-90.
4. **Image reconstruction and compressed sensing** The real-time and short T2 work both required the development of image reconstruction methods, such as improvements to gridding reconstruction for non-Cartesian imaging (a). More recently work has been in compressed sensing, where spatial frequency data is randomly undersampled, and then reconstructed using an optimization approach (b). This can be combined with parallel imaging (c) to provide and additional factor of 2-4 beyond what parallel imaging alone can do. A major application of these techniques is pediatric imaging, where faster acquistions allow anesthesia or sedation to be eliminated (d).
    a. "Rapid gridding reconstruction with a minimal oversampling ratio." Beatty PJ, Nishimura DG, Pauly JM. *IEEE Trans Med Imaging*. 2005 Jun;24(6):799-808. PMID: 15959939

b. "Sparse MRI: The application of compressed sensing for rapid MR imaging." Lustig M, Donoho D, Pauly JM. *Magn Reson Med.* 2007 Dec;58(6):1182-95.PMID: 17969013
c. "SPIRiT: Iterative self-consistent parallel imaging reconstruction from arbitrary k-space." Lustig M, Pauly JM. *Magn Reson Med*. 2010 Aug;64(2):457-71. PMID: 20665790
d. "Improved pediatric MR imaging with compressed sensing." Vasanawala SS, Alley MT, Hargreaves BA, Barth RA, Pauly JM, Lustig M. *Radiology*. 2010 Aug;256(2):607-16. PMID: 20529991

5. **MR systems instrumentation and MR guided interventions** One of the major applications of real-time imaging is MR guided interventions. We have been working on doing RF ablations at the MR Larmor frequency (a) for the treatment of metasteses to the liver. We have also been working on the safety of both implanted and interventional devices in an MRI scanner (b,c), including the use of parallel transmit arrays to minimize the potential for device heating (d).
   a. "RF field visualization of RF ablation at the Larmor frequency." Shultz K, Stang P, Kerr A, Pauly J, Scott G. *IEEE Trans Med Imaging*. 2012 Apr;31(4):938-47. PMID: 21775256
   b. "Ensuring safety of implanted devices under MRI using reversed RF polarization." Overall WR, Pauly JM, Stang PP, Scott GC. *Magn Reson Med.* 2010 Sep;64(3):823-33. PMID: 20593374
   c. "Offline impedance measurements for detection and mitigation of dangerous implant interactions: an RF safety prescreen." Ellenor CW, Stang PP, Etezadi-Amoli M, Pauly JM, Scott GC. Magn Reson Med. 2015 Mar;73(3):1328-39. PMID: 24623586
   d. "Controlling radiofrequency-induced currents in guidewires using parallel transmit." Etezadi-Amoli M, Stang P, Kerr A, Pauly J, Scott G. *Magn Reson Med.* 2014 Dec 17. PMID: 25521751

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/john.pauly.1/bibliography/41160185/public/?sort=date&direction=ascending
Google Scholar Link
http://scholar.google.com/citations?user=Fc6GIIQAAAAJ&hl=en

Ongoing Research Support

R01EB008108 Pauly (PI) 10/1/07-1/31/16
MRI Technology For Enhanced Radio Frequency Safety
This project aims to develop methods for detecting and predicting heating on implanted devices, and interventional devices during MR procedures. Role: Principal Investigator. This is in NC extension.

GE Medical Systems Research Grant Nishimura (PI) 1/1/15-12/31/17
Improved MR Imaging Systems
Study and implement novel approaches to MRI to increase clinical capabilities in significant areas.
Role: Co-Investigator

P41 EB015891 Glover (PI) 1/1/95-5/31/20
Center for Advanced Magnetic Resonance Technology at Stanford
The major goals of this project are to develop innovative MR techniques, and to serve the academic and scientific community through collaborations, education and access to Center facilities and resources.
Role: Co-Investigator, Core 1 Director

1R01EB009690 Vasanawala (PI) 4/1/10-12/31/17
Rapid Robust Pediatric MRI
This project aims to combine high channel coil receive arrays with compressed sensing at 3T, in order to make MRI fast enough to be able to scan a much larger number of pediatric patients, who would otherwise go to CT.
Role: Investigator.

P01 CA159992 (K Butts Pauly, PI) 7/01/11-6/30/16
Magnetic Resonance Imaging-Guided Cancer Interventions
This project aims to develop and test controlled minimally invasive thermal ablation techniques for the treatment of cancer. Five projects in this PPG include: 1) MR-guided HIFU of soft tissue tumors, 2) Minimally Invasive MRI-Guided Management of Prostate Disease, 3) MR-Guided Precision Thermal Therapy of Retroperitoneal Tumors, 4) MRI Methods for Guiding Focused Ultrasound in the Brain and 5) MR-guided RF Ablation. The outcomes of this PPG will be 1) improved minimally-invasive treatment options, 2) an increase in

the basic science understanding of tissue response to thermal treatments, and 3) advances in engineering, both hardware and software, specifically for treatment of these cancers.
Role: Project 5 leader, Core B Investigator

Subcontract to R01 EB017449 (Vigneron, UCSF) 8/15/13-7/30/18
Development and Translation of Hyperpolarized C-13 Prostate Cancer MRI Methods
This subcontract supports the development of hyperpolarized C-13 for cancer detection and staging. The focus of the subcontract is on RF pulse design, acquisition methods, and image reconstruction algorithms.
Role: Stanford Subcontract PI

R01 EB017739-01 (PI: Brian Hargreaves, Ph.D.) 7/1/14-6/30/18
NIH / NIBIB
Comprehensive MRI near Total Joint Replacements
This project seeks to make routine MRI available for patients with total hip replacements and total knee replacements, including fast, high-resolution imaging and temperature mapping.
Role: Co-Investigator

R01EB019241 (Co-MPIs Vasanawala and Pauly) 7/1/14-6/30/19
NIH/NIBIB
Development and Translation of High Performance Receive Arrays for Pediatric MRI
This BRP project aims to develop high-performance, flexible, completely wireless receive arrays for pediatric imaging using printed electronics for coils fabrication, wireless power delivery, and low power receive electronics.
Role: Co-MPI

GE Medical Systems Research Grant Vasanawala (PI) 1/1/15-12/31/16
Wireless Receiver Coil Transponders for MRI
This project is a one year systems study of wireless receive arrays, with a focus on identifiying, testing, and initial development of the components that will be required for these systems to be successful. This project provided initial data and systems architectures that are included in this proposal.
Role: Investigator

<u>Completed Research Support</u>

DARPA ENCIDE Program, BAA-13-01 (Arbabian, PI) 5/1/13-10/31/14
Enabling Non-Contact Imaging For Detection Of Explosives (Encide)
The aims of this project are to develop non-contact methods for detecting explosives inside bodies using various methods including magneto-acoustic imaging and microwave-acoustic imaging methods.
Role: Investigator

Subcontract to R01EB009756 (Xu, UCSF) 09/01/09-6/30/14
Development of Advanced Techniques for MR of the Newborn Brain
This project aims to develop new MR methods for imaging neonates. The subcontract concerns improvements in diffusion weighted MRI for infants, and the development of improved parallel reconstruction algorithms for the very highly parallel imaging arrays that are being developed under the parent project.
Role: Stanford Subcontract PI

R01EB006471 Pauly (PI) 10/01/07-5/31/12
Imaging Brain Activation with Steady-State Free Precession MRI
The Goal of this project is to develop new ways to imaging brain activation using steady-state free precession MRI, in order to provide greater sensitivity and resolution. In no-cost extension. Role: Principal Investigator

R21 EB007715 Pauly (PI) 9/1/07 – 1/31/12
MRI-Guided, Robotically Controlled Cardiac Ablation
The goal of this proposal is to develop the technology for MR guided, robotically controlled ablation for performing electrophysiology procedures to correct heart rhythm abnormalities. Role: Principal Investigator.

Subcontract to R01EB007588 (Vigneron, UCSF) 07/01/07-6/31/12
Technique Development For Hyperpolarized C-13 MR Studies
This project aims to develop new MR methods for imaging hyperpolarized C13. This subcontract concerns the development of new RF pulses for C13 spectroscopic imaging pulse sequences. Role: PI on Subcontract