OMB No. 0925-0001/0002 (Rev. 08/12 Approved Through 8/31/2015)

BIOGRAPHICAL SKETCH

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NAME: Nayak, Krishna Shrinivas

eRA COMMONS USER NAME: knayak@usc.edu

POSITION TITLE: Professor of Electrical Engineering, Biomedical Engineering, and Radiology

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Florida State University, Tallahassee, Florida	B.S.	06/1995	Electrical Engineering, Comp. Sci., and Math
Stanford University, Stanford, California	M.S.	05/1996	Electrical Engineering
Stanford University, Stanford, California	Ph.D.	01/2001	Electrical Engineering

A. Personal Statement

I have the expertise, leadership, and motivation necessary to successfully carry out the proposed research project. I serve as a Professor of Electrical Engineering, and as Director of the Magnetic Resonance Engineering Laboratory at the University of Southern California. I have significant expertise (15+ years) developing and clinically translating novel MRI technology. My major contributions to date involved pulse sequence design, data sampling and reconstruction, and artifact mitigation, which are all topics central to the proposed work. My laboratory has a diverse portfolio of projects, and our common mission is to develop enabling MRI technology (primarily rapid and quantitative imaging techniques), and to work closely with experts from other disciplines to translate and validate this technology. I have a successful track record of collaboration including projects, publications, and grants, with cardiologists, radiologists, pulmonologists, obesity researchers, otolaryngologists, endocrinologists, linguists, and MRI technicians. I have served as Co-investigator on several R01 projects and have served as PI on two successful R21 projects and several foundation grants. This proposal builds on my 4-year collaboration with Co-Is Meng Law and Mark Shiroishi (Neuroradiology), and 2-year collaboration with Co-I Justin Haldar (Electrical Engineering), and a recent CTSI-funded pilot study that I led. I feel qualified to serve as PI because of my strong track record developing and translating new MRI methods (numerous papers, patents, conference proceedings), because of my experience leading interdisciplinary projects including the pilot study that provided the preliminary data.

1. Y Guo, Y Zhu, SG Lingala, RM Lebel, KS Nayak. "Highly Accelerated Brain DCE MRI with Direct Estimation of Pharmacokinetic Parameter Maps." *Proc. ISMRM 23rd Scientific Sessions,* Toronto, June 2015, p573.
2. SG Lingala, Y Guo, Y Zhu, S Barnes, RM Lebel, KS Nayak. "Accelerated DCE MRI Using Constrained Reconstruction Based On Pharmacokinetic Model Dictionaries." *Proc. ISMRM 23rd Scientific Sessions*, Toronto, June 2015, p196.
3. Y Guo, RM Lebel, Y Zhu, MS Shiroishi, M Law, KS Nayak. "High-resolution Whole-brain DCE MRI of Brain Tumor using Constrained Reconstruction: Prospective Clinical Evaluation." *Proc. ISMRM 23rd Scientific Sessions*, Toronto, June 2015, p3050.
4. RM Lebel, J Jones, JC Ferre, M Law, KS Nayak. “Highly accelerated dynamic contrast enhanced imaging.” *Magnetic Resonance in Medicine*. 71(2):635-644. February 2014.

B. Positions and Honors

Professional Positions:

2001-2003 Research Associate and Lecturer, Electrical Engineering, Stanford University
2003-2009 **Assistant Professor**, Electrical Engineering, University of Southern California

2009-2014 **Associate Professor**, Electrical Engineering, University of Southern California
2010-2011 Sabbatical, Laboratory for Cardiac Energetics, Intramural Division, NIH/NHLBI
2014- **Professor**, Electrical Engineering, University of Southern California
(with courtesy appointments in Biomedical Engineering and Radiology)

Other Experience and Professional Memberships:

1996- Member, International Society for Magnetic Resonance in Medicine
2000- Member, Society for Cardiovascular Magnetic Resonance, Science Committee (2007-2011)
2000- Member, Institute for Electrical and Electronics Engineers, Senior Member (2008-present)
2000- Member, American Heart Association
2006- Member, American Association for the Advancement of Science
2011- Member, American Society for Engineering Education
2000- Journal Referee: MRM, JMRI, IEEE-TMI, MAGMA, Radiology, Inv. Radiology, JCMR, Circ Imaging, JACC Cardiov Imaging.
2006- Workshop Organization: ISMRM Workshops on Real-Time MRI (Chair, 2006); Non-Cartesian MRI (2007), Data Sampling (2009); High-Field CMR (2006, 2008, 2010, 2013); Non-Contrast CMR (2015).
2007- AHA Peer Review Committee: Nat'l RadSurg (Fall 2007, Spr 2008), Western Bioeng (Spr 2010)
2009- NIH Peer Review Committee: SBIBL30 (Nov 2009), ZHL1 ad hoc (Feb 2010), ZRG SBIBU55 (Jun 2010), ZHL1 CCT-N C2B (Feb 2012), CHL1 CCT-H C4 (Feb 2013), ZHL1 CCT-Q C1 (Sep 2013), ZRG1 DTCS-A 81S (Feb 2015) mail review
2015- Member, DCE-MRI Task Force, Radiological Society of North America (RSNA) Quantitative Imaging Biomarkers Alliance (QIBA)

Honors and Awards:

1995-1996 Tau Beta Pi #11 Centennial Graduate Fellowship
1995-2000 Fannie and John Hertz Foundation Graduate Fellowship
2001 Fannie and John Hertz Foundation Doctoral Thesis Prize
2007 USC Viterbi School of Engineering Junior Faculty Research Award
2008 USC-Mellon Mentoring Award, Faculty Mentoring of Graduate Students
2009 GE Healthcare Magnetic Resonance Thought Leader Award
2011 NAE Frontiers in Engineering Education Attendee
2013-2016 USC Center for Excellence in Teaching, Faculty Fellow
2014 USC Community Engagement Award

C. Contributions to Science

1. Spiral-based methods for Real-Time Interactive Cardiac MRI. My first contributions were to real-time interactive MRI of the heart, with the goal of achieving the speed and convenience of ultrasound. This involved acquiring, reconstructing, and displaying images faster than the underlying motion (10 to 50 frames per second) with low latency (less than 0.5 second). I designed new techniques for real-time interactive imaging of intra-cardiac flow, coronary arteries, heart wall motion, for the guidance of interventional procedures, and imaging at 3 Tesla. Some elements have been commercialized by a startup company, HeartVista Inc. At USC, my group developed methods for automatic artifact correction that are particularly useful when calibration information cannot be acquired at every scan plane.

    a. KS Nayak, JM Pauly, AB Kerr, BS Hu, and DG Nishimura. Real-Time Color Flow MRI. *Magnetic Resonance in Medicine*. 2000:43:251-258. February 2000.
    b. KS Nayak, BS Hu, and DG Nishimura. Rapid Quantitation of High-Speed Flow Jets. *Magnetic Resonance in Medicine*. 2003:50:366-372. August 2003.
    c. KS Nayak, CH Cunningham, JM Santos, and JM Pauly. Real-Time Cardiac Imaging at 3 Tesla. *Magnetic Resonance in Medicine*. 2004:51(4):655-660. April 2004.
    d. KS Nayak, BA Hargreaves, BS Hu, DG Nishimura, JM Pauly, and CH Meyer. Spiral Balanced Steady-State Free Precession Cardiac Imaging. *Magnetic Resonance in Medicine*. 2005:53(6):1468-1473 June 2005.

2. Improved Pulse Sequences for Cardiac MRI at 3 Tesla. Shortly after the FDA approval of 3 Tesla MRI (2003), I developed methods and calibration procedures for more reliable cardiac MRI at 3 Tesla. My group developed a new method for measuring non-uniformities of the transmitted RF field, and reported consistent patterns of variation across the heart at 3T. We optimized RF pulses used in cardiac MRI based on a measured B0-B1 "footprint", which is an approach that other groups now use to ensure robust RF pulse performance. We also developed a method for widening the spectral pass-band of balanced SSFP to overcome the "banding" artifacts often seen in cardiac CINE imaging. We also helped develop clinical 3T cardiac MRI protocols, including techniques for first-pass perfusion.

   a. CH Cunningham, JM Pauly, KS Nayak. Saturated Double Angle Method for Rapid B1+ Mapping. *Magnetic Resonance in Medicine*. 2006:55(6):1326-1333. June 2006.
   b. KH Sung and KS Nayak. Measurement and characterization of RF non-uniformity over the heart at 3T using body coil transmission. *Journal of Magnetic Resonance Imaging* 27(3):643-648. March 2008.
   c. T Shin, HH Hu, GM Pohost, KS Nayak. "Three dimensional first-pass myocardial perfusion imaging at 3T: feasibility study." *Journal of Cardiovascular Magnetic Resonance* 10:57. December 11th, 2008.
   d. KS Nayak, HL Lee, BA Hargreaves, BS Hu. Wideband SSFP: alternating repetition time balanced steady state free precession imaging with increased band spacing. *Magnetic Resonance in Medicine* 58(5):931-938. November 2007.

3. Application of MRI to the Upper Airway Vocal Tract. My group has made major advances in the MRI of the upper airway and vocal tract, for two applications: 1) the dynamics of vocal tract shaping during speech production (http://sail.usc.edu/span), and 2) the dynamics of airway collapse in obstructive sleep apnea. The airway is challenging for MRI because there is substantial off-resonance due to magnetic susceptibility (e.g. at air-tissue interfaces, the exact locations of interest). My group produced the first non-invasive real-time movies of natural speech, and have developed several enhancements including noise-robust audio recording, multi-slice imaging, adaptive temporal resolution acquisition, custom RF coils, and audio-based temporal alignment. My group produced the first non-invasive real-time movies of naturally occurring airway collapse events in patients with OSA (without sedation), and has developed several enhancements including experiment designs for airway compliance testing, and estimation of regional critical closing pressure.

   a. Y-C Kim, RM Lebel, Z Wu, SL Davision Ward, MCK Khoo, KS Nayak. "Real-time 3D MRI of the Pharyngeal Airway in Sleep Apnea." *Magnetic Resonance in Medicine*. 71(4):1501-1510. April 2014.
   b. Z Wu, Y-C Kim, MCK Khoo, KS Nayak. "Evaluation of an Independent Linear Model for Acoustic Noise on a Conventional MRI Scanner and Implications for Acoustic Noise Reduction." *Magnetic Resonance in Medicine*. 71(4):1613-1620. April 2014.
   c. E Bresch, YC Kim, KS Nayak, D Byrd, S Narayanan, "Seeing speech: capturing vocal tract shaping using real-time magnetic resonance imaging," *IEEE Signal Proc. Mag.,* 25(3):123-132. May 2008.
   d. S Narayanan, KS Nayak, S Lee, A Sethy, D Byrd. An Approach to Real-Time Magnetic Resonance Imaging for Speech Production. *Journal of the Acousitcal Society of America*. 2004:115(5):1771-1776. April 2004.

4. Myocardial Perfusion Imaging with Arterial Spin Labeling. My group has been actively developing human myocardial perfusion imaging techniques based on arterial spin labeling (ASL). We have developed a pulse sequence and protocol that is compatible with adenosine stress testing, and is simple to run. With this, we have validated measurements of normal myocardial perfusion in humans and developed schemes for measuring regional temporal SNR, a widely used surrogate for sensitivity. We also have performed a clinical pilot study data suggestive that single-slice cardiac ASL is capable of differentiating ischemic and normal myocardium based on perfusion reserve.

   a. HP Do, A Javed, TR Jao, H-W Kim, PK Garg, AJ Yoon, KS Nayak. "Arterial Spin Labeling CMR Perfusion Imaging is Capable of Continuously Monitoring Myocardial Blood Flow during Stress." *Proc. SCMR 18th Scientific Sessions*, Nice, February 2015, P145.
   b. HP Do, TR Jao, KS Nayak. "Myocardial Arterial Spin Labeling Perfusion Imaging with Improved Sensitivity." *Journal of Cardiovascular Magnetic Resonance*. 16:15. January 2014.

c. Z Zun, P Varadarajan, RG Pai, EC Wong, KS Nayak. "Arterial Spin Labeling Cardiac Magnetic Resonance Detects Clinically Relevant Increases in Myocardial Blood Flow With Vasodilation." *Journal of the American College of Cardiology: Cardiovascular Imaging* 4(12):1253-1261. December 2011.
d. Z Zun, EC Wong, KS Nayak. "Measurement of Myocardial Blood Flow in Humans using Arterial Spin Labeling: Feasibility and Noise Analysis," *Magnetic Resonance in Medicine* 62(4):975-83. October 2009.

5. Body Composition Assessment. My group has investigated MRI methods for quantifying body fat distribution, with the goal of facilitating the study of what regulates fat accumulation in various organs and fat pads. We experimentally validated the IDEAL fat-water separation method for liver fat measurement in humans, validated fat mass measurements against chemical assay in animals, demonstrated methods for registration and intra-subject registration**,** and methods for identifying brown fat and its activation. I now support the use of fat-water separated MRI in several obesity intervention studies at USC, including bariatric surgery, and nutrition and exercise interventions.

a. HH Hu, HW Kim, KS Nayak, MI Goran, "Comparison of 3D Fat-Water MRI and Single-Voxel MRS in the Assessment of Hepatic and Pancreatic Fat Fraction," *Obesity*, 18(4):841-847. April 2010.
b. K-A Le, EE Ventura, JQ Fisher, JA Davis, MJ Weigensberg, M Punyanita, HH Hu, KS Nayak, MI Goran. "Ethnic differences in pancreatic fat accumulation and its relationship with other fat depots and inflammatory markers," Diabetes Care 34:485-490, February 2011.
c. CM Toledo-Corral, TL Alderete, HH Hu, KS Nayak, S Esplana, T Liu, MI Goran, MJ Weigensberg. "Ectopic Fat Deposition in Pre-diabetic Overweight and Obese Minority Adolescents." *Journal of Clinical Endocrinology & Metabolism.* 98(3):1115-1121. March 2013.
d. AA Joshi, HH Hu, MI Goran, RM Leahy, KS Nayak. "Automatic intra-subject registration-based segmentation of abdominal fat from 3D water-fat MRI." *Journal of Magnetic Resonance Imaging* 37:423-430, February 2013.

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/krishna.nayak.1/bibliography/41148689/public/?sort=date&direction=descending

D. Research Support

Ongoing Research Support

NIH/NIDDK R01 DK097115 J Wood (PI) 9/13 – 8/17
Optimizing Tissue Iron Quantification at 3 Tesla
This will cross validate MRI R2 and R2* measurements at 3T (against 1.5T), and will develop new methods for imaging high tissue iron concentrations.
Role: Co-Investigator

NIH/NHLBI R01 HL105201 M Khoo (PI) 9/10 – 8/15
Model-based Phenotyping of OSAS in Pediatric Obesity using Dynamic MR Imaging
This study combines computational modeling, state-of-the-art real-time MRI, and physiological monitoring to investigate why obese children with sleep-related breathing disorders exhibit large variations in sleep and clinical characteristics
Role: Co-Investigator

NIH/NIDCD R01 DC007124 S Narayanan (PI) 5/05 – 11/20
Dynamics of Vocal Tract Shaping
This goal of this project is to wed state-of-the-art technology for imaging the vocal tract with a linguistically formed analysis of speech tasks of goals requisite in the production of spoken language.
Role: Co-Investigator

NIH/NIDDK U01 DK094430 T Buchanan, A Xiang (PI) 9/11 – 6/16

β-cell Preservation through Fat Mitigation
This grant supports the conduct of a clinical trial to compare gastric banding to pioglitazone treatment for preservation or restoration of β-cell function in people with pre- or mild type 2 diabetes.
Role: Co-Investigator

AHA/West 13GRNT13850012 K Nayak (PI) 1/13 – 12/15
Myocardial ASL Perfusion Imaging with Increased Coverage and Sensitivity
The goal of this project is to improve the coverage and sensitivity of arterial spin labeled myocardial perfusion imaging by developing and validating techniques that suppress background signals and reduce measurement noise.
Role: Principal Investigator

Wallace Coulter Foundation K Nayak (PI) 9/12 – 8/15
Myocardial Perfusion Imaging without Contrast Agents, Phase 2
The goal of this project is to develop and commercialize new tools for measuring regional myocardial blood flow without contrast agents (based on arterial spin labeled MRI), which can be safely used in patients with end-stage renal disease.
Role: Principal Investigator

NSF/DGE GK12 NSF 0948037 K Nayak (PI) 6/11 – 5/16
BE-LA: Body Engineering, Los Angeles
The goal of this project is to develop a sustainable program that will develop the leadership, collaboration, and communication skills of top engineering PhD students, while introducing cutting edge body engineering research and providing mentorship in urban Los Angeles middle school classrooms.

Completed Research Support

NIH/NCATS UL1TR00130 K Nayak (PI of Pilot Study) 7/13 – 6/15
CTSI Pilot Study: Improved DCE Neuro-MRI using Constrained Reconstruction
This goal of this project was to apply sparse sampling and constrained reconstruction to dynamic contrast enhanced (DCE) MRI of the brain, and obtain pilot data in patients with brain tumor.
Role: Principal Investigator of Pilot

NIH/NIBIB R21 EB 013456 M Law (PI) 1/12 – 12/13
Novel ICA Based Multi-fiber Streamline Tractography Approach
The goal is to develop, test and validate a new ICA based method to estimate the orientations of multiple fibers within a voxel using clinically acquired DTI data in 5-7 minutes. Simulations, phantom and human studies will be conducted.
Role: Co-Investigator

NIH/NIDDK R01 DK05911 M Goran (PI) 10/09 – 9/14
Risk Factors for Type-II Diabetes in Hispanic Adolescents
The goal of this project is to examine the role of body fat, visceral fat, physical activity and insulin action and secretion in the development of type 2 diabetes during puberty.
Role: Co-Investigator

NIH/NIDDK R21 DK081173 K Nayak (PI) 2/09 – 12/12
Rapid MRI Measures of Absolute Fat Mass in Adipose Tissue and Organs
The goal of this project is to develop and evaluate new methods for rapidly quantifying abdominal fat distribution (including organ fat mass fraction) using MRI. Validation will be performed in swine using chemical assay as the reference.
Role: Principal Investigator