Michael (Miki) Lustig

CONTACT INFORMATION	Room 506, Cory Hall EECS Department University of California Berkeley, CA 94720 USA	*Tel:* *E-mail:* *WWW:*	510-643-9338 mlustig@eecs.berkeley.edu http://www.mlustig.com

RESEARCH
INTERESTS

My research interests lie in the broad area of signal and image processing. More specifically, my interest is in developing and improving the numerous theoretical and practical aspects of imaging systems and, in particular, the application of Compressed Sensing (CS) to imaging. My projects so far have focused on magnetic resonance imaging (MRI), where I was the first to develop and demonstrate the application of compressed sensing to rapid MRI. In addition I developed parallel imaging reconstruction techniques, image artifacts reduction methods, motion estimation and correction techniques, novel RF-excitation pulses, rapid MRI pulse sequence design and improved functional MRI techniques.

EDUCATION

Stanford University, Stanford, California USA

> Ph.D., Electrical Engineering, August 2008
> M.Sc., Electrical Engineering, June 2004

Technion IIT, Haifa, Israel

> BSc., *cum laude*, Electrical Engineering, June 2001

HONORS AND
AWARDS

- Thomas Schwartz award for distinguished projects, Techion IIT, 2001
- Winner of the Texas instruments *DSP and analog Challenge* world wide competition receiving a 100,000$ prize for the project: *Real-time digital watermarking for audio signals*, Dallas Texas, USA, August 2001
- GE Healthcare Thought Leader award for ground-breaking work in compressed-sensing MRI, 2009.
- Lauterbur Award for best paper on MR, SCBT-MR scientific meeting, 2009, titled "Faster Pediatric MRI with Compressed Sensing"
- Caffy Award for best pediatric radiology research, Society of Pediatric Research, 2009, titled "Faster Pediatric MRI with Compressed Sensing"
- Winner of the MRI reconstruction challenge, 2010 Annual meeting of the ISMRM

POSITIONS

University of California, Berkeley, Berkeley, California USA

Assistant Professor **2009 - present**
Department of Electrical Engineering and Computer Science.

Stanford University, Stanford, California USA

Visiting Assistant Professor **2009 - present**
Department of Electrical Engineering.

Engineering Research Associate **2008 - 2009**
Developing rapid magnetic resonance imaging techniques, advanced image reconstructions, massive coil array processing, and non-rigid body motion correction techniques with focus on robust pediatric MRI.

Research Assistant **2003 - 2008**
Developed methods for rapid magnetic resonance imaging. I was the first to develop and demonstrate the application of compressed sensing to MRI. In addition, developed methods for image artifacts

suppression, motion correction and several pulse design techniques. These resulted in six issued and pending US patents. Primary advisor: John M. Pauly and secondary advisor: David L. Donoho

Jigami Ltd, Haifa, Israel

DSP engineer **2000 - 2001**
Developed advanced image compression techniques for internet content over wireless networks. In particular, studied image compression schemes at low bit-rate compression and implemented them on a DSP-based system.

Israeli Defense Forces, Israel

Infantry Officer (rank: Captain) **1992 - 1997**

ACADEMIC
ACTIVITIES

Teaching
- EE290T/BIOE265, *Principles of Magnetic Resonance Imaging*, Spring 2010

Invited Talks
- *Sparse MRI*, plenary talk, Workshop on Novel Reconstruction Strategies in NMR and MRI" Gottingen, Germany, September 2010
- *Compressed Sensing in Medical Imaging: Progress in Applications and Implementation*, Tutorial, SIAM Annual Meeting, Pittsburgh, PA, July 2010
- *Compressed Sensing*, Workshop on Accelerated Medical Imaging, University of Wisconsin, Madison, WI, June 2010
- *A Compressed Tour of Compressed Sensing for Rapid MRI*, ISL Colloquium, Stanford University, January 2010
- *A Compressed Tour of Compressed Sensing for Rapid MRI*, EECS Colloquium, UC Berkeley, October 2009
- *Sparse MRI*, plenary talk, Workshop on Dictionary of Atoms: New Trends in Advanced Signal Processing in Functional Brain Imaging, Universite de Montreal, Canada, September 2009
- *Compressed Sensing*, plenary talk, annual meeting of the European Society of Magnetic Resonance in Medicine and Biology, Antalia, Turkey, September 2009
- *Compressed Sensing for Rapid MRSI Acquisitions*, The Second International Workshop on Hyperpolarized Carbon-13 and its Applications in Metabolic Imaging, Philadelphia, PA, July 2009
- Frontiers in Rapid MRI, HSEMB Conference, Houston, TX, March 2009
- *Assumptions and Stability of Model-Based Reconstruction*, ISMRM Workshop on Data Sampling and Image Reconstruction, January 2009
- *A Compressed Tutorial on Rapid MRI: From Basic Principles to Parallel Imaging and Compressed Sensing*, International Conference on Image Processing (ICIP) San-Diego, October 2008
- *Compressed Sensing*, International Society of Magnetic Resonance in Medicine annual meeting, Toronto, May 2008

PATENTS

1 Tao Zheng, **Michael Lustig** and John Pauly, *Autocalibrating Parallel Imaging Reconstruction Method from Arbitrary K-space Sampling with Reduced Noise*, US Patent Pending

2 Tolga Cukur and **Michael Lustig** *Contrast and Resolution Enhancement of Magnetization-Prepared MRI with Signal Compensation*, US Patent Pending 12/789,315

3 William Grissom, **Michael Lustig**, Yoav Medan, and Kim B. Pauly *Hybrid Referenceless and Multibaseline PRF-Shift MR Thermometry*, Provisional US Patent Pending

4 **Michael Lustig**, Charles H Cunningham, Albert Chen, Daniel Vigniron, and John M Pauly *Optimized Spectral Spatial Pulse Design*, US Patent Pending

5 **Michael Lustig**, Simon Hu, Daniel Vigniron and John M Pauly *Blip design for random sam-*

pling compressed sensing of flyback 3D-MRSI with application to Hyperpolarized ^{13}C, US Patent 7,659,718

6 **Michael Lustig**, and John M Pauly, *An Auto-calibrating Parallel Imaging Reconstruction Method from Arbitrary k-Space* , US patent Pending 20090196478

7 **Michael Lustig**, Seung-Jean Kim and John M Pauly, *MRI method of determining time-optimal gradient waveforms with gradient amplitude as a function of arc-length in k-space*, US Patent 7,791,338

8 **Michael Lustig** and Charlse H Cunningham, *Butterfly: A Self Navigating Cartesian Trajectory*, US Patent 7,692,423

9 **Michael Lustig**, Juan M Santos, David L Donoho and John M Pauly, *k-t SPARSE: High Frame Rate Dynamic MRI Exploiting Spatio-Temporal Sparsity*, US Patent 7,602,183

10 **Michael Lustig** and John M Pauly, *Artifact Reduction in SSFP MRI Using Super Field of View Reconstruction*, US Patent 7,132,828

PUBLICATIONS

11 William A Grissom , Viola Rieke, Andrew B Holbrook, Yoav Medan, **Michael Lustig**, Juan M Santos, Mike V McConnel and Kim Butts Pauly *Hybrid Referenceless and Multibaseline subtraction MR Thermometry for Monitoring Thermal Therapies in Moving Organs*, Medical Physics, 2010;37(9):5014-26

12 Peder E. Z. Larson, Simon Hu, **Michael Lustig**, Adam B. Kerr, Sarah J. Nelson, John Kurhanewicz, John M. Pauly and Daniel B. Vigneron, *Fast Dynamic 3D MR Spectroscopic Imaging with Compressed Sensing and Multiband Excitation Pulses for Hyperpolarized 13C Studies*, Magnetic Resonance in Medicine, 2010 Early view DOI: 10.1002/mrm.22650

13 Mariya Doneva, Peter Bornert, Holger Eggers, Alfred Mertins, John M Pauly and **Michael Lustig**, *Compressed Sensing for Chemical Shift based Water-Fat Separation*, Magnetic Resonance in Medicine, 2010, Early view PMID 20859998.

14 William A Grissom, **Michael Lustig**, Andrew B Holbrook, Viola Rieke, John M Pauly and Kim Butts-Pauly *Reweighted ℓ_1 referenceless PRF Shift Thermometry*, Magnetic Resonance in Medicine, 2010, Oct;64(4):1068-77

15 **Michael Lustig** and John M. Pauly *SPIRiT: autocalibrating iTerative Self-consistent Parallel Imaging Reconstruction from Arbitrary k-Space*, Magnetic Resonance in Medicine, 2010, Aug;64(2):457-71

16 Shreyas S Vasanawala, Marc T Alley, Richard A Barth, John M Pauly and **Michael Lustig**, *Improved Pediatric MR Imaging with Compressed Sensing*, Radiology, 2010 Aug;256(2):607-16

17 Peder EZ Larson, Robert Bok, Adam B Kerr, **Michael Lustig**, Simon Hu, Albert P Chen, Sarah J Nelson, John M Pauly, John Kurhanewicz and Daniel B Vigneron *Investigation of Tumor Hyperpolarized [1-13 C]-Pyruvate Dynamics Using Time-Resolved Multiband RF Excitation Echo-Planar MRSI*, Magnetic Resonance in Medicine, 2010 March; 63(3): 582-591

18 Simon Hu, **Michael Lustig**, Asha Balakrishnan, Peder EZ Larson, Robert Bok, John Kurhanewicz, Sarah J. Nelson, Andrei Goga, John M. Pauly, Daniel B. Vigneron *3D Compressed Sensing for Highly Accelerated Hyperpolarized 13C MRSI with in vivo Applications to Transgenic Mouse Models of Cancer*, Magnetic Resonance in Medicine, 2010 Feb;63(2):312-21

19 Daeho Lee, **Michael Lustig**, William Grissom and John M. Pauly *Time-Optimal Design for Multidimensional and Parallel Transmit Variable Rate Selective Excitation*, Magnetic Resonance in Medicine, 2009;61(6):1471-9.

20 Tolga Cukur, **Michael Lustig** and Dwight G. Nishimura *Improving Non-contrast-enhanced*

Steady-state Free Precession Angiography with Compressed Sensing, Magnetic Resonance in Medicine, 2009;61(5):732-8.

21 Peder EZ Larson, **Michael Lustig** and Dwight G. Nishimura *Anisotropic Field-of-View Shapes for Improved PROPELLER Imaging*, Magnetic Resonance Imaging, 2008;27(4):470-9

22 **Michael Lustig** *Sparse MRI*, PhD Thesis, Department of Electrical Engineering Stanford University, 2008

23 Jongho Lee, **Michael Lustig**, Dong-hyun Kim and John M. Pauly *Improved Shim Method Based on the Minimization of the Maximum Off-resonance Frequency for Balanced SSFP*, Magnetic Resonance in Medicine, 2009;61(6):1500-6

24 Tolga Cukur, **Michael Lustig** and Dwight G. Nishimura *Multiple-profile Homogeneouse Image Combination: Application to Phase-cycled SSFP and Multi-coil Imaging*, Magnetic Resonance in Medicine, 2008;60(3): 732-8

25 Peder E. Z. Larson, Adam Kerr, Albert P. Chen, **Michael Lustig**, Matthew L. Zierhut, Simon Hu, Charles .H. Cunningham, John M. Pauly, John Kurhanewicz, and Daniel B. Vigneron *Multiband Excitation Pulses for Hyperpolarized 13C Dynamic Chemical Shift Imaging* Journal of Magnetic Resonance, 2008;194(1): 121-127

26 **Michael Lustig**, Seung-Jean Kim and John M Pauly, *A Fast Method for Designing Time-Optimal Gradient Waveforms for Arbitrary k-Space Trajectories*, Transactions on Medical Imaging, 2008; 27(6): 866-873

27 Charles H. Cunningham, Albert P. Chen, **Michael Lustig**, Janine Lupo, Duan Xu , John Kurhanewicz, Ralph E. Hurd, John M. Pauly, Sarah J. Nelson and Daniel B. Vigneron *Pulse Sequence for Dynamic Volumetric Imaging of Hyperpolarized Metabolic Products* , Journal of Magnetic Resonance, 2008;193(1): 139-146

28 Simon Hu, **Michael Lustig**, Albert P. Chen, Jason Crane, Adam Kerr, Douglas A.C. Kelley, Ralph Hurd, John Kurhanewicz, Sarah J. Nelson, John M. Pauly, Daniel B. Vigneron *Compressed Sensing for Resolution Enhancement of Hyperpolarized ^{13}C Flyback 3D-MRSI*, Journal of Magnetic Resonance, 2008;192(2): 258-264

29 Seung-Jean Kim, K. Koh, **Michael Lustig**, Stephen Boyd and D. Gorinevsky *A Method for ℓ^1-regularized Least-Squares*, IEEE Journal of Selected Topics in Signal Processing, 2007 Dec.;1(4): 606-617

30 **Michael Lustig**, David L. Donoho, Juan M. Santos and John M. Pauly *Compressed Sensing MRI*, IEEE Signal Processing Magazine, 2008; 25(2): 72-82

31 **Michael Lustig**, David L. Donoho and John M. Pauly, *Sparse MRI: The Application of Compressed Sensing for Rapid MR Imaging*, Magnetic Resonance in Medicine, 2007 Dec.; 58(6):1182-1195

32 Juan M. Santos, Charlse H. Cunningham, **Michael Lustig**, Brian A. Hargreaves, Bob S Hu, Dwight G. Nishimura and John M. Pauly, *Single Breath-Hold Whole-Heart MRA Using Variable-Density Spirals at 3T*, Magnetic Resonance in Medicine, 2006; 55:371-379

SELECTED
CONFERENCE
PROCEEDINGS

33 P Lai, **M Lustig**, A Brau, S Vasanawala, PJ Beatty, M Alley, *Efficient ℓ_1-SPIRiT Reconstruction (ESPIRiT) for Highly Accelerated 3D Volumetric MRI with Parallel Imaging and Compressed Sensing*, in proceedings of the ISMRM 2010, pp. 345

34 **M Lustig**, J Velikina, A Samsonov, C Mistretta, JM Pauly, M Elad, *Coarse-To-Fine Iterative Reweighted L1-Norm Compressed Sensing for Dynamic Imaging*, in proceedings of the ISMRM 2010, pp. 4892

35 M. Murphy, K. Keutzer, S. Vasanawala, **M. Lustig**, *Clinically Feasible Reconstruction Time for L1-SPIRiT Parallel Imaging and Compressed Sensing MRI*, in proceedings of the ISMRM 2010, pp. 4854

36 M. Doneva, P. Bornert, H. Eggers, A. Mertins, JM Pauly, **Michael Lustig**, *CS-Dixon: Compressed Sensing for Water-Fat Dixon Reconstruction*, in proceedings of the ISMRM 2010, pp. 2919

37 **M Lustig** , M Elad, JM Pauly, Calibrationlless Parallel Imaging Reconstruction by Structured Low-Rank Matrix Completion, in proceedings of the ISMRM 2010, pp. 2870

38 **M Lustig**, M. Alley, S. Vasanawala, D. Donoho and JM Pauly, ℓ_1 *SPIRiT: Autocalibrating Parallel Imaging Compressed Sensing*, in proceedings of the ISMRM 2009

39 **M Lustig**, S-J Kim, and JM Pauly, *A Fast Method for Designing Time-Optimal Gradient Waveforms for Arbitrary k-Space*, in proceedings of the ISMRM 2008

40 **M Lustig** and JM Pauly, *Further Advances in Parallel Imaging Reconstruction from Arbitrary kSpace Trajectories* in Proceedings of the ISMRM Workshop on Non Cartesian MRI 2007

41 **M Lustig**, DL Donoho and JM Pauly *Multi-Slice Compressed Sensing Imaging*, in proceedings of the ISMRM 2007

42 **M Lustig** and JM Pauly, *Iterative GRAPPA: a General Solution for the GRAPPA Reconstruction from Arbitrary k-Space Sampling*, in proceedings of the ISMRM 2007

43 **M Lustig**, CH Cunningham, BS Hu and JM Pauly, *Multiple Narrow-Band Excitations Spiral Imaging*, in proceedings of ISMRM 2007

44 **M Lustig**, E Daniyaldaze, CH Cunningham and JM Pauly, *Butterfly MRI: A Self Navigating Cartesian Trajectory*, in proceedings of the ISMRM 2007

45 **M Lustig**, JM Santos, DL Donoho and JM Pauly, *k-t SPARSE: High Frame Rate Dynamic MRI Exploiting Spatio-Temporal Sparsity*, in proceedings of the ISMRM, 2006

46 **M Lustig**, DL Donoho and JM Pauly, *Rapid MR Imaging with Compressed Sensing and Randomly Under-Sampled 3DFT Trajectorie*, in proceedings of the ISMRM, 2006

47 **M Lustig**, CH Cunningham and JM Pauly, *A Monte-Carlo Algorithm for Designing Ultra-High Time-Bandwidth, Minimum Peak $|B_1|$, Selective Saturation and Inversion RF-Pulses*, in proceedings of the ENC, 2006

48 **M Lustig**, DL Donoho and JM Pauly, *Rapid MR Angiography with Randomly Under-Sampled 3DFT Trajectories and Non-Linear Reconstruction*, in proceedings of the SCMR, 2006

49 **M Lustig** ,JM Santos, JH Lee, DL Donoho and JM Pauly, *Compressed Sensing for Rapid MR Imaging*, in proceedings of SPARS'05, 2005

50 **M Lustig**, JM Santos and JM Pauly, *A Super-FOV Method for Rapid SSFP Banding Artifact Reduction*, in Proceedings of the ISMRM, 2005.

51 **M Lustig**, JH Lee, DL Donoho and JM Pauly, *Faster Imaging with Randomly Perturbed, Undersampled Spirals and ℓ^1 Reconstruction*, in proceedings of the ISMRM, 2005

52 **M Lustig**, J Tsaig, JH Lee, DL Donoho, *Fast Spiral Fourier Transform for Iterative MR Image Reconstruction*, in proceedings of the IEEE International Symposium on Biomedical Imaging, 2004

53 **M. Lustig** Y Cassuto and S. Mizrachi, *Real-time digital watermarking of audio signals*, in proceedings of the 3rd European DSP Research and Education Conference, 1999