

Raj Rao Nadakuditi
Electrical Engineering Faculty Candidate
Massachusetts Institute of Technology
Phone: 857 891 8303, Email: raj@mit.edu

Research Focus

The development and analysis of statistical signal processing algorithms using random matrix theory. The longer term objectives are to:

1. Understand the fundamental limits of signal versus noise discrimination using limited observations,
2. Develop implementable algorithms that are able to operate efficiently at these limits,
3. Test and refine these algorithms using real-world experiments and archival data sets and,
4. Distill the emerging theory of (non-commutative) “free” probability and “free” information theory into engineering applications.

Education

Massachusetts Institute of Technology Ph.D in Electrical Engineering and Computer Science MIT/WHOI Joint Program in Applied Ocean Science and Engineering Advisor: Prof. Alan Edelman Thesis title: Applied Stochastic Eigen-Analysis	<i>Cambridge, MA February 2007</i>
Massachusetts Institute of Technology SM in Electrical Engineering and Computer Science Advisor: Dr. James Preisig Thesis title: A channel subspace filtering approach to adaptive equalization	<i>Cambridge, MA February 2002</i>
Lafayette College BS in Electrical Engineering with Honors Minor in Mathematics Thesis title: Modal power distribution in optical fibers at a bend	<i>Easton, PA May 1999</i>

Work Experience

Massachusetts Institute of Technology, Post-doctoral research associate (with Profs. Arthur Baggeroer and Alan Edelman)	<i>Cambridge, MA Oct. 2006 - Present</i>
Qualcomm, Inc. Systems Engineering Group Intern (GSM Technologies)	<i>San Diego Summer 2003</i>
Aware, Inc. DSL Modem Algorithm Development team	<i>Bedford, MA Oct. 2001 – Nov. 2002</i>

Honors and Distinctions

- Shortlisted for the (triennial) Householder Best Dissertation Award (2008)
- Office of Naval Research Post-Doctoral Fellowship Award (2006-2008)
- Office of Naval Research Graduate Student Traineeship Award (1999-2002)
- Lawrence J. Conover '24 Electrical Engineering Prize (1999). This is awarded to a student upon recommendation of the Department of Electrical Engineering.
- Finley W. and Ethelwyne H. Smith Electronic Engineering Prize (1999). This is awarded to a senior with the highest cumulative grade point average.
- Woods Hole Oceanographic Institution Summer Student Fellowship (1998)
- IEEE Award (Third Prize) for Student Paper Presentation Contest (1999)
- IEEE Award (Third Prize) for Student Paper Presentation Contest (1998)
- IEEE Award (Second Prize) for Robotics Contest (1998)
- IEEE Award (Third Prize) for Robotics Contest (1998)
- Academic Honor Societies: Eta Kappa Nu (Electrical Engineering), Tau Beta Pi (Engineering), Pi Mu Epsilon (Mathematics), Phi Beta Kappa (Liberal Arts), Omicron Delta Epsilon (Economics)

Workshops Co-Organized

ABBFest'08 Workshop on current trends and future directions in acoustics, signal processing and underwater communications (1 day, 12 speakers, 50 attendees)	<i>Cambridge, MA October 25, 2008</i>
FoCM'08 Workshop on Stochastic Eigen-Analysis (3 days, 13 speakers, 35 attendees)	<i>Hong Kong, China June 24-26, 2008</i>
SEA'06 Workshop and Summer School on Stochastic Eigen-Analysis and Its Applications (5 days, 38 speakers, 175 attendees)	<i>Cambridge, MA July 10-14, 2006</i>
SEA'05 Workshop on Robust Signal Processing and Stochastic Eigen-Analysis (2 days, 26 speakers , 75 attendees)	<i>Cambridge, MA October 14-15, 2005</i>
FoCM'05 Workshop on Stochastic Eigen-Analysis and Its Applications (3 days, 15 speakers, 45 attendees)	<i>Santander, Spain July 4-6, 2005</i>

Publications

Journal Publications

- “Fundamental limit of generalized sample eigenvalue based detection of high-dimensional signals in colored noise using relatively few samples,” (with Jack Silverstein), *IEEE Transactions on Signal Processing*, Under Review.
- “The analytic computability of the Shannon transform for a large class of random matrix channels,” *IEEE Communications Letters*, Under Review
- “The polynomial method for random matrices,” (with Alan Edelman), *Foundations of Computational Mathematics*, Accepted for publication. To appear in 2008.
- “Statistical eigen-inference from large Wishart matrices,” (with Alan Edelman, Roland Speicher and James Mingo), *Annals of Statistics*, Accepted for publication. To appear in 2008.
- “Multiplication of free random variables and the S-transform: the case of vanishing mean,” (with Roland Speicher), *Electronic Communications in Probability*, vol. 12, pages 248-258, 2007.
- “Sample eigenvalue based detection of high-dimensional signals in white noise using relatively few samples,” (with Alan Edelman), *IEEE Transactions on Signal Processing*, vol. 56, no. 7, pages 2625 – 2638, July 2008.
- “Random Matrix Theory,” (with Alan Edelman), *Acta Numerica*, Vol. 14, pages 233-297, May 2005. (Invited Survey paper)
- “A channel subspace post-filtering approach to adaptive least-squares estimation,” (with James C. Preisig), *IEEE Transactions on Signal Processing*, vol. 52, no. 7, pages 1901-1914, July 2004.

Conference Publications

- “Robust vector sensor processing in presence of mismatch and finite samples,” (with Andrew Poulsen and Arthur Baggeroer), *Proceedings of the Sensor Array Multichannel Processing Workshop*, Darmstadt, Germany, July 2008.
- “Fundamental limit of sample eigenvalue based detection of signals in arbitrary noise using relatively few samples,” (with Jack Silverstein), *Proceedings of the Asilomar Conference of Signals and Systems*, November 2007.
- “Sample size cognizant detection of signals in noise,” (with Alan Edelman), *Proceedings of the Signal Processing Advances in Wireless Communications Conference*, Helsinki, Finland, July 2007.
- “Free Probability, Sample Covariance Matrices and Signal Processing,” (with Alan Edelman), *Proceedings of ICASSP*, Toulouse, France, May 2006.
- “The asymptotic mean squared error performance of the diagonally loaded Capon-MVDR processor,” (with Christ Richmond and Alan Edelman), *Proceedings of the Asilomar Conference of Systems and Signals*, November 2005.
- “On the probability distribution of the Capon-MVDR beamformer outputs under diagonal loading,” (with Alan Edelman), *Proceedings of the Asilomar Conference of Systems and Signals*, November 2005.
- “The bias of the MVDR beamformer outputs under diagonal loading,” (with Alan Edelman), *Proceedings of ICASSP*, March 2005.
- “The polynomial method: from theory to the ‘free’ calculator,” *Oberwolfach Reports*, Vol. 2, Issue 2, 2005.

Talks

Invited Talks

- “The finite sample induced breakdown of detection theory in large systems,” ABBFest, Cambridge, MA, October 2008
- “Applied Stochastic EigenAnalysis,” University of Massachusetts, Dartmouth, April 2008
- “Applied Stochastic EigenAnalysis,” University of Rochester, Rochester, NY, February 2008
- “Fundamental limits of eigen-detection,” New Frontier Advisors, Boston, October 2007
- “Statistical Eigen-inference from large Wishart matrices,” Institute of Mathematical Statistics Meeting, Salt Lake City, Utah, August 2007
- “Deconvolution of eigen-spectra,” Adaptive Sensor Array Processing Workshop, Lexington, MA, June 2007
- “Eigen-inference from financial time series,” Acadian Asset Management Seminar, February 2007
- “Eigen-inference from financial time series,” JP Morgan Investment Management Corporation, February 2007
- “Statistical Eigen-inference from large Wishart matrices,” Multivariate Statistical Methods in the 21st Century, Indian Institute of Statistical Sciences, December 2006
- “A conjectured maximum entropy-like characterization of spacing distributions,” Luminy conference on random matrices, Luminy, France, October 2006
- “Statistical Eigen-inference from large Wishart matrices,” SAMSI Workshop, September 2006
- “Eigen-inference from financial time series,” Morgan Stanley Quantitative Finance Seminar, November 2006
- “Statistical eigen-inference from large random matrices,” GAMM-SIAM Conference on Applied Linear Algebra and Its Applications, July 2006
- “Free Probability, Sample Covariance Matrices and Signal Processing,” Special Session on Algebra and Signal Processing, ICASSP 2006, Toulouse, France, May 2006
- “Eigenvector statistics, the Mexican bus system and acoustic resonances in quartz blocks,” Smart Antennas Research Group, Stanford University, November 2005
- “Free probability computations and random matrices,” Fields Institute Summer School on Operator Algebras, Ottawa, Canada, June 2005
- “Stochastic Eigen-Analysis and Robust Signal Processing,” Department of ECE, Queens University, Kingston, Canada, May 2005
- “Stochastic Eigen-Analysis and Robust Signal processing,” Stochastic Systems Group, MIT, April 2005
- “The polynomial method: from theory to the free calculator,” Free Probability Workshop, Mathematisches Forschungsinstitut Oberwolfach, Germany, March 2005

Contributed Talks

- “Robust vector sensor processing in presence of mismatch and finite samples,” Sensor Array Multichannel Processing Workshop, Darmstadt, Germany, July 2008
- “Analytical prediction of sample eigenvector degradation due to sample size/SNR constraints,” Acoustics’08 conference, Paris, June 2008
- “Fundamental limit of sample eigenvalue based detection of signals in arbitrary noise using relatively few samples,” Asilomar Conference of Signals and Systems, November 2007
- “Sample size cognizant detection of signals in noise,” Signal Processing Advances in Wireless Communications Conference, Helsinki, Finland, July 2007
- “On the probability distribution of the outputs of the Capon-MVDR processor under diagonal loading,” Asilomar Conference of Systems and Signals, November 2005
- “The probability distribution of the MVDR beamformer outputs under diagonal loading,” SEA’05 Workshop, MIT, October 2005

- “The polynomial method: from theory to the free calculator,” Random Matrices Workshop, Foundations of Computational Mathematics Conference, Santander, Spain, July 2005
- “The probability distribution of the MVDR beamformer outputs under diagonal loading,” ASAP 2005, MIT Lincoln Laboratory, May 2005
- “The bias of the MVDR beamformer outputs under diagonal loading,” ICASSP 2005, Philadelphia, March 2005
- “The polynomial method for random matrices,” Bernoulli Conference, Barcelona, Spain, August 2004
- “A channel subspace post-filtering approach to the equalization of rapidly varying channels,” Asilomar Conference of Systems and Signals, November 2001
- “A channel subspace post-filtering approach to tracking rapidly-varying channels,” Acoustic Society of America Conference, Chicago, June 2001

Other Workshop Participation

- Workshop on Free Probability, Extensions and Applications, Banff, Canada, January 2008
- SAMSI Closing Workshop on Random Matrices and High-dimensional inference, AIM, Palo Alto, April 2007

Curriculum Development and Teaching Experience

- Spring 2003 & Fall 2003: *Eigenvalues of Random Matrices* (with Prof. Alan Edelman)
- Spring 2004 & 2005 *Finite Random Matrix Theory and Its Applications* (with Prof. Alan Edelman)
- Fall 2004 & 2005 *Infinite Random Matrix Theory and Its Applications* (with Prof. Alan Edelman)
- Fall 2008 *Eigenvalues of Random Matrices* (with Prof. Alan Edelman)

Tutorial Lectures

Statistical and Mathematical Sciences Institute (SAMSI) Undergraduate Workshop on Random Matrices and High Dimensional Inference (25 attendees)	<i>Raleigh, NC November 2006</i>
International Conference on Acoustics Speech and Signal Processing (ICASSP) Finite and Infinite Random Matrix Theory (50 attendees)	<i>Philadelphia, PA March 2005</i>
American Mathematical Society Mathfest Summer Course on Random Matrices (40 attendees)	<i>Providence, RI August 2004</i>

Patents

- Application 20050025076, “Scaling and quantizing soft-decision metrics for decoding” (with Arunava Chaudhary of Qualcomm, Inc.)

Professional Activities

Reviewed articles for the

- IEEE Transactions on Signal Processing
- IEEE Signal Processing Letters
- IEEE Transactions on Information Theory
- Annals of Applied Probability
- SIAM Journal of Matrix Analysis and Applications
- International Symposium of Information Theory
- IEEE Sensor Array and Multichannel Processing Workshop

Member of Governing Council of the Society of the Foundations of Computational Mathematics

References

1) Prof. Alan Edelman,
Department of Mathematics & Computer Science,
Massachusetts Institute of Technology,
77 Massachusetts Avenue,
Cambridge, MA 02142.
Email: edelman@math.mit.edu
Phone: 617 253 7770

2) Prof. Arthur Baggeroer,
Department of EECS and Mechanical Engineering,
Massachusetts Institute of Technology,
77 Massachusetts Avenue,
Cambridge, MA 02142.
Email: abb@boreas.mit.edu
Phone: 617 253 4336

3) Prof. Iain Johnstone,
Department of Statistics,
Stanford University,
Sequoia Hall, 390 Serra Mall,
Stanford, CA 94305-4065.
Email: imj@stat.stanford.edu
Phone: 650 723 9114

4) Dr. James Preisig,
Applied Ocean Physics and Engineering,
Woods Hole Oceanographic Institution,
MS - 11, Bigelow 207,
Woods Hole, MA 02543.
Email: jpreisig@whoi.edu
Phone: 508 289 2736

5) Prof. Sanjoy Mitter,
Department of EECS,
Massachusetts Institute of Technology,
77 Massachusetts Avenue,
Cambridge, MA 02142.
Email: mitter@mit.edu
Phone: 617 253 2160

6) Dr. Christ Richmond,
Advanced Sensor Techniques - Group 103,
MIT Lincoln Laboratory,
244 Wood Street, Rm S4-317,
Lexington, MA 02420.
Email: christ@ll.mit.edu
Phone: 781 981 5954

7) Prof. Roland Speicher,
Department of Mathematics and Statistics,
Queen's University,
Kingston, Ontario K7L 3N6. Canada.
Email: speicher@mast.queensu.ca
Phone: 613 533 2388