
Curriculum Vitae

Balu Santhanam

Department of Electrical & Computer Engineering
University of New Mexico, Albuquerque, NM: 87131 - 1356
Tel: (505) 277 - 1611, Fax: (505) 277 - 8298
Email: bsanathan@unm.edu
Web: www.ece-research.unm.edu/bsanathan

EDUCATION

- **Georgia Institute of Technology**, Atlanta, GA.
Ph.D. in Electrical Engineering, March 21, 1998.
Thesis: *Multicomponent AM-FM Energy Demodulation with Applications to Signal Processing and Communications.*
Advisor: **Prof. Petros Maragos**,
Co-advisor: **Prof. James McClellan**
- **Georgia Institute of Technology**, Atlanta, GA.
M.Sc. in Electrical Engineering, March 1994.
- **Saint Louis University**, Saint Louis, Missouri.
B.Sc. in Electrical Engineering. May 1992.

EXPERIENCE

1. Associate Professor of Electrical Engineering, Department of E.C.E., UNM (May 2005 - Present).
2. Gardner-Zemke Professorship, for excellence in teaching, curriculum development, and engineering education (2016-2019).
3. Assistant Professor, Department of E.C.E., UNM, Aug 1999 - May 2005.
4. Post-doctoral researcher, Department of E.C.E., University of California, Davis (98-99) and independent consultant, SSI Inc, Napa Valley, California (98-99).
5. Graduate research assistant, School of E.C.E., Georgia Institute of Technology, Atlanta, Georgia (92-98).
6. Grading Assistant, Saint Louis University, Saint Louis, Missouri (91-92).

FUNDING

Grants and Proposals

1. Around 1.55M USD worth of sponsored research projects from several funding agencies such as AFRL, DOE, NSF, BigCrow, and NCMR.
2. Active Grants:
 - (a) PI on grant entitled, "A Dual Stage Linear Predictive Approach Towards Wideband FM Demodulation with Multilevel and Partial Response Signaling," Source of Support: AFRL, Total award amount: \$57,000.00, Award period: 03/01/2016 - 05/2017.
 - (b) PI on grant entitled, "Multirate Signal Processing Enabled Wideband FM Demodulation for Satellite Communications, " Source of Support: AFRL, Total Award Amount: \$99,857.00, Award Period: 03/01/14 - 07/29/16.

- (c) Co-PI (with Majeed Hayat) on DOE grant entitled: “Remote Detection and Recognition of Concealed Machinery: A Co-registered Vibration-Estimation and Imaging Approach,” \$165,000, May 2014 - May 2017.

3. Completed Grants:

- Co-PI on contract from NCMR administered through the NPS, “Co-registered Vibrometry and Imaging Using Synthetic Aperture Radar: A Fractional-Fourier Transform Approach,” Amount: \$44,182.00, duration: Aug 11 2012 - July 12, 2013.
- Co-PI on contract through MASINT, “Co-registered Vibrometry and Imaging using Synthetic Aperture Radar: A Fractional-Fourier Transform Approach,” Amount: \$107,042.00, duration: June 2008 - July 2011.
- Co-PI on contract through NNSA (DOE) via project entitled, “Algorithms and methodologies for Detecting Vibrations Using Synthetic Aperture Radar,” Amount: \$122,006.00, duration: Sep 2008 - Sep 2011.
- PI on contract through OptiMetrics Inc, via grant entitled, “A Hybrid ICA and Machine Learning Approach Towards Vibration Based Engine Type Classification,” start date: 07/2008, \$47,266, Index code: 271241.
- PI on “An Overview of Modulation Classification Algorithms,” Miratek Corp, AFRL, \$218,816 start date: Nov 2005, end date: 12/2008, Index code: 271107.
- Co-PI on UNM/UCLA ARO–MURI grant with Steve Brueck (CHTM), H.Y. Tran on “Deep Sub-wavelength Optical Nanolithography,” \$450,000, start date: Fall 2000, end date: Summer 2004.
- PI on grant with AFRL on “Digital signal processing techniques for design of DRFM devices for high frequency radar applications,” \$159,252.00, start date: Aug 2002, end date: June 2006.
- PI on grant sponsored by Management Scientific Inc., on the development of a portable “airline wire quality monitor,” \$23,330, start date: May 2002, end date: Dec 2002.
- PI on “Instantaneous Feature Extraction for Classification of Engine Noise Vibrations,” with Majeed Hayat, Optometrics Inc., AFRL, \$60,030, start date: Oct 2005, end date: May 2007.

Honors and Affiliations

- Recipient of the 2016, ECE Gardner Zemke teaching award for excellence in teaching and education.
- Recipient of the 2000 and 2005, ECE outstanding teaching award.
- Recipient of the 2012, ECE, Lawton-Ellis award for combined excellence in teaching, research, and professional/community service.
- Nominee for the 2011, ECE, Gardner-Zemke award, and the 2011, UNM Teacher of the year award.
- Creative award, May 2013, from STC-UNM for US patents: 8,814,927.B2 and 8,208,724.B2.
- Creative award, May 2012, from STC-UNM for US patents: 7,961,975.B2.
- Professional society activities:
 - **Senior member of the IEEE** and the IEEE signal processing, communications, and information theory societies.
 - Member of the American Society for Engineering Education (ASEE).
 - Member of SPIE, the International Society for Optical Engineering.
 - Associate editor, International Journal on Computers and Electrical Engineering, Elsevier Science, period: (2000-2009).
 - Chair, IEEE Signal processing and Communications society, local Albuquerque chapter, Feb 2009 - Feb 2014.

PUBLICATIONS

Journal Articles

Published

1. B. Santhanam and J.H. McClellan, "Discrete Rotational Fourier Transformation," *IEEE Transactions on Signal Processing*, Vol. 44, No. 4, pp. 994 - 997, April 1996.
2. B. Santhanam and P. Maragos, "Energy Demodulation of Two-component AM-FM Signal Mixtures," *IEEE Signal Processing Letters*, Vol. 3, No. 11, pp. 294 - 298, Nov 1996.
3. B. Santhanam and P. Maragos, "Harmonic Analysis and Restoration of Separation Methods for Periodic Signal Mixtures: Algebraic Separation vs Comb Filtering," *Signal Processing*, Vol. 69, No. 1, pp. 81-91, 1998.
4. B. Santhanam and P. Maragos, "Multicomponent AM-FM Demodulation Via Periodicity-based Algebraic Separation and Energy-based Demodulation," *IEEE Transactions on Communications*, Vol. 48, No. 3, pp. 473-490, 2000.
5. Balu Santhanam, "Generalized Energy Demodulation for Large Frequency Deviations and Wideband Signals," *IEEE Signal Processing Letters*, Vol. 11, No. 3, pp. 341-344, March 2004.
6. J. G. Vargas* and Balu Santhanam, "On the Multiangle Centered Discrete Fractional Fourier Transform," *IEEE Signal Processing Letters*, Vol. 12, No. 4, pp. 273-276, April 2005.
7. E. -T. Wu*¹, B. Santhanam, and S. R. J. Brueck, "Characterization of Imaging interferometric Lithography and Optimization in Simulation" *Journal of Microlithography, Microfabrication, and Microsystems*, Vol. 4, No. 2, 023009, April-June, 2005.
8. T. M. Tridhavee*, Balu Santhanam, and S. R. J. Brueck, "Optimal Frequency Coverages and Parsings for Imaging Interferometric Lithography," *Journal of Microlithography, Microfabrication, and Microsystems*, Vol. 4, No. 3, 033005, July-September, 2005.
9. O. Lankoande, Majeed Hayat, and Balu Santhanam, "Scene Estimation From Speckled Synthetic Aperture Radar Imagery: A Markov-Random-Field Approach," *J. Opt. Soc. Amer. A*, Vol. 23, No. 6, pp. 1269-1281, June 2006.
10. B. Santhanam and T. S. Santhanam, "On Discrete Gauss-Hermite Functions and Eigenvectors of the Discrete Fourier Transform," *Signal Processing*, Vol. 88, No. 11, pp. 2738-2746, Nov. 2008. Erratum to "On Discrete Gauss Hermite Functions and Eigenvectors of the Discrete Fourier Transform," *Signal Processing*, Vol. 89, pp. 352, 2009.
11. David Boutte and Balu Santhanam, "A Hybrid ICA-SVM Approach to Continuous Phase Modulation Recognition," *IEEE Signal Processing Letters*, Vol. 16, No. 5, pp. 402-405, 2009.
12. T. S. Santhanam and Balu Santhanam, "Quantum Mechanical Oscillator in a Finite Dimensional Hilbert Space," *Journal of Physics A: Mathematical and Theoretical*, Vol. 42, No. 20, DOI: 205303, May 2009.
13. Q. Wang, M. Pepin, R. Beach, R. Dunkel, T. Atwood, B. Santhanam, W. Gerstle, and M. M. Hayat, "SAR-based Vibration Estimation using the Discrete Fractional Fourier Transform," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 50, No. 10, pp. 4145-4156, Oct., 2012.
14. Balu Santhanam, "On Orthogonal Modes of Continuous and Discrete Frequency Modulation," *IEEE Transactions on Signal Processing*, Vol. 60, No. 7, pp. 3486-3495, July 2012.
15. Qi Wang, M. Pepin, A. Wright, R. Dunkel, T. Atwood, B. Santhanam, W. Gerstle, A. Doerry, and M. M. Hayat, "Reduction of Vibration Induced Artifacts in Synthetic Aperture Radar Imagery," *IEEE Transactions on Geoscience and Remote Sensing*, pp. 3063-3073, Vol. 52, No. 6, June 2014.
16. Wenjing Liu and Balu Santhanam, "Wideband Image Demodulation Via Bi-dimensional Multirate Frequency Transformations" *Journal of the Optical Society of America A*, Vol. 33, No. 9, pp. 1668-1678, Sep., 2016.

¹asterisk marks papers published or submitted with students

Acronym for publication	Bibtex Acronym	Number of citations	Acronym for publication	Bibtex Acronym	Number of Citations
TSP-96	SaMc96	169 times	DSP-02	SaGu02	2 times
SPL-96	SaMa96	25 times	JOSA-06	LHS06	3 times
TCOM-00	SaMa00	85 times	JOSA-17	LiSa17	2 times
SPL-05	VaSa05	80 times	ASIL-14	JSH14	3 times
ICASSP-95	SaMc95	42 times	ASIL-12	WSPH12	5 times
ASIL-04	GuSa04b	23 times	ASIL-09	Santh09	3 times
DSP-04	GuSa04	24 times	DSP-06	LSH06	8 times
SigProc	SP98	20 times	ICIP-05		5 times
ICASSP-04	SaVa04	12 times	ICASSP-96	SaMa96	7 times
ICASSP-05	VaSa05b	28 times	SPIE-03	WSB03	3 times
ICASSP-07	SaSa07	24 times	SPIE-11	Wang11	5 times
ICASSP-97	SaMa97	10 times	MLITH-03	WSB03	3 times
DSP-04	VaSa04	17 times	MLITH-04	TSB04	5 times
SPL-04	Santh04	18 times	SPIE-09	Wang09	9 times
SP-08	SaSa08	26 times	ASIL-00	Santh00	2 times
SMC-05		19 times	JM3-05	TSB05	2 times
SPIE-10	Wang10	12 times	ASIL-09	Santh09	3 times
IGARSS-11	Wang11	13 times	NSIP-95	MPS95	8 times
SPIE-05	LHS05	10 times	DSP-11	SaHa11	8 times
SPL-09	BoSa09b	29 times	WCNC-06a	GuSa06a	3 times
DSP-09	BoSa09a	13 times	WCNC-06b	GuSa06b	2 times
TGRS-12	Wang12	41 times	DSP-15	BhSa15	3 times
TGRS-14	Wang14	19 times	DSP-13a	ASH13	4 times
SIP-11	PeSa11	11 times	DSP-13c	Santh13	2 times
ASIL-03	GuSa03	10 times	TSP-12	Santh12	3 times
DSP-13b	PeSa13	10 times			

Figure 1: Citation index for journal and conference publications, source: Google Scholar. Total number of citations is 938. Citations for Ph.D thesis, patents, and single citations are not listed. Citations correspond to a h-index of 17.

17. F. Perez, B. Santhanam, R. Dunkel, M. M. Hayat, "Clutter Suppression via Hankel Rank Reduction for DFrFT-Based Vibrometry Applied to SAR," *IEEE Geoscience and Remote Sensing Letters*, Vol. 14, No. 11, pp. 2052-2056, Nov., 2017.
18. J. Cambell, F. Perez, Qi. Wang, R. Dunkel, A. Doerry, T. Atwood, M. Hayat, "Remote Vibration Estimation Using Displaced Phase Center Antenna SAR for Strong Clutter Environments," *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 56, No. 5, pp. 2735-2747, May 2018.
19. Wenjing Liu and Balu Santhanam, "Wideband Partial Response CPM Demodulation Via Multirate Frequency Transformations and Decision Feedback Equalization," *To Appear Eurasip Journal on Wireless Communications and Networking*, 2018.

Papers Under Review or in Progress

Technical Reports and Books

- Balu Santhanam, "Nonstationary Signal Analysis, Energy Demodulation, and the Multicomponent AM-FM Signal Model," EECE Department Technical Report: EECE-TR-01-001, Dec 2001.
- O. Lankoande, M. M. Hayat, and Balu Santhanam, "Speckle Reduction of SAR Images Based on a Combined Markov Random Field and Statistical Optics Approach," EECE-TR-2004-21: ECE Technical Report.
- Balu Santhanam and Juan G. Vargas-Rubio*, "On the Grunbaum Commutator Based Discrete Fractional Fourier Transform," EECE-TR-2004-22: ECE Technical Report.

- Balu Santhanam and Thalanayar S. Santhanam, “On Discrete Gauss-Hermite Functions and Eigenvectors of the Discrete Fourier Transform,” ECE Technical report: <http://hdl.handle.net/1928/2974>.
- Balu Santhanam, “On Orthogonal Modes of Continuous and Discrete Frequency Modulation,” ECE technical report: <http://hdl.handle.net/1928/12924>.

Reviewed Conference Papers

1. B. Santhanam and T.S. Santhanam, “A Note on the Angular Fourier Transformation,” *Proceedings of the Int’l Workshop on Harmonic Oscillators*, Cocoyoc, Mexico, pp. 249 - 254, March 1994.
2. B. Santhanam and J.H. McClellan, “The DRFT - A rotation in Time - Frequency Space,” *Proceedings of IEEE-ICASSP95*, Vol. 2, pp. 921 - 925, May 1995.
3. P. Maragos, A. Potamianos and B. Santhanam, “Instantaneous Energy Operators: Applications to Speech Processing and Communications,” *Proceedings of NSIP-95*, Athens, Greece.
4. B. Santhanam and P. Maragos, “Energy Demodulation of Two-component AM-FM Signals with Application to Speaker Separation,” *Proceedings of IEEE-ICASSP96*, pp. 3518 - 3521, May 1996.
5. B. Santhanam and P. Maragos, “Demodulation of Discrete Multicomponent AM-FM Signals Using Periodic Algebraic Separation and Energy Demodulation,” *Proceedings of IEEE-ICASSP97*, pp. 2409 - 2412, Munich, Germany, April 1997.
6. B. Santhanam, “Algebraic Separation Applied to Concurrent Vowel Separation and ECG Signal Separation,” *Proc. of Asilomar-2000*, Vol. 2, pp. 1507-1511, Nov 2000.
7. Balu Santhanam, “Component Enumeration of Multicomponent AM-FM Signals Via Generalized Energy Operators,” *Proceedings of IEEE-ICASSP-02*, Vol. 2, pp. 1437-1440, May 2002.
8. B. Santhanam and J. R. Vargas*, “On the Grunbaum Tridiagonal Commutator Based Discrete Fractional Fourier Transform,” *Proc. of ICASSP-2004*, Vol. II, pp. 641-644, Montreal, Canada, May 2004.
9. B. Santhanam and M. Gupta*, “Energy Separation and Demodulation of CPM Signals,” *Proc. of 10th IEEE DSP Workshop*, Pine Mountains, Georgia, pp. 20-23, Oct, 2002.
10. Eric Wu*, Balu Santhanam and S. R. J. Brueck, “Grating Analysis of Frequency Parsing Strategies for Imaging Interferometric Lithography,” *Proc. of SPIE Conference on Optical Microlithography*, Vol. 5040, pp. 1276-1283, Feb 2003.
11. Malay Gupta* and Balu Santhanam, “Adaptive Linear Predictive Frequency Tracking Based CPM Demodulation,” **Invited Paper**, *Proc of ACSSC-2003*, Vol. 1, pp. 202-206, Nov 2003.
12. T. M. Tridhavee*, Balu Santhanam, S. R. J. Brueck, “Optimization and Apodization of Aerial Images at high NA in Imaging Interferometric Lithography,” *Proc. of SPIE conference on Optical Microlithography*, Vol. 5377, pp. 1544-1554, May 2004.
13. J. G. Vargas-Rubio* and Balu Santhanam, “The Centered Discrete Fractional Fourier Transform and Linear Chirp Signals,” *Proc. of 11th IEEE DSP and SP Education Workshop*, pp. 163-167, Taos Ski Valley, New Mexico, Aug, 2004.
14. Malay Gupta* and Balu Santhanam, “ICA Based Blind Adaptive MAI Suppression in DS-CDMA Systems,” *Proc. of 11th IEEE DSP and SP Education Workshop*, pp. 201-205, Taos Ski Valley, New Mexico, Aug 2004.
15. Malay Gupta* and Balu Santhanam, “Prior ICA Based Blind Multiuser Detection in DS-CDMA Systems,” *Proc. of ACSSC-04*, Vol. 2, pp. 2155-2159, Nov 2004.
16. Malay Gupta*² and Balu Santhanam, “On the Unimodality of Deflation Based Fast-ICA Contrast,” *Proc. of ACSSC-05*, pp. 237-241, Nov 2005.
17. J. G. Vargas-Rubio* and Balu Santhanam³, “An Improved Spectrogram Using the Multiangle Centered Discrete Fractional Fourier Transform,” *Proc. of ICASSP-05*, Vol. IV, pp. 505-508, Philadelphia, March 2005.

²This paper was nominated for best student paper award at the Asilomar Conference on Signals Systems and Computers, Pacific Grove, CA, Nov. 2005.

³This paper was considered for best student paper award in the SPTM technical area.

18. O. Lankoande, Majeed Hayat, and Balu Santhanam, "Speckle Reduction of SAR images using a Physically based Markov Random Field Model and Simulated Annealing," *Proc. of SPIE Conference on Algorithms for Synthetic Aperture Radar Imagery XII*, Vol. 5808, pp. 210-221, May 2005.
19. O. Lankoande, Majeed Hayat, and Balu Santhanam, "Speckle Noise Modelling and Reduction in Synthetic Aperture Radar Imagery," *Proceedings of ICIP-05*, Vol. III, pp. 317-320, Aug 2005.
20. O. Lankoande, Majeed Hayat, and Balu Santhanam, "Segmentation of SAR Images Based on a Markov Random Field Model," *Proc. IEEE Conference on SMC*, pp. 2956-2961, Oct 2005.
21. Malay Gupta and Balu Santhanam, "A General Approach Towards Blind Multiuser Detection Using Higher Order Statistics," *Proc. IEEE WCNC 2006*, Vol. 3, pp. 1585-1590, April 2006.
22. Malay Gupta and Balu Santhanam, "Hebbian Learning Based Blind Adaptive Multiuser Detection in DS-CDMA systems," *Proc. of IEEE WCNC 2006*, Vol. 2, pp. 1102-1107, April 2006.
23. S. L. Reddy, Balu Santhanam, and Majeed Hayat, "Multicomponent Chirp Demodulation Using Discrete Fractional Fourier Analysis," *Proc. of 12th IEEE DSP and SP Education Workshop*, Wyoming, pp. 418-422, Sep 2006.
24. B. Santhanam and T. S. Santhanam, "Discrete Gauss-Hermite Functions and Eigenvectors of the Centered Discrete Fourier Transform," *Proc. of ICASSP-07*, Vol. 3, pp.1385-1388, April 2007.
25. David Boutte and Balu Santhanam, "ISI Effects in a Hybrid ICA-SVM Modulation Recognition Algorithm," *Proc. of Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, pp. 457-460, Oct., 2008.
26. David Boutte and Balu Santhanam, "A Feature Weighted Hybrid ICA Approach to Automatic Modulation Recognition," *Proc. of IEEE DSP & SP Education Workshop*, pp. 399-403, Jan. 2009.
27. S. L. Reddy, B. Santhanam, and M. Hayat, "CoChannel FM Demodulation Via the Multiangle Discrete Fractional Fourier Transform," *Proc. of IEEE DSP & SP Education Workshop*, Marcos Island, Florida, pp. 535-539, Jan. 2009.
28. Ousseini Lankoande, Majeed Hayat, and Balu Santhanam, "A Markov Random Field Based Filter for Speckle Reduction in Ultrasound Imagery," *Proc. of SPIE Symposium on Medical Imaging*, Vol. 7265, pp. 72650H-72650H-10, 2009.
29. Q. Wang, M. Hayat, B. Santhanam, and T. Atwood, "SAR Vibrometry Using Fractional Fourier Transform Processing," *To Appear: Proc. of SPIE Defense and Security Symposium*, Vol. 73 08, pp. 73080B-73080B-9, Orlando, Florida, April 2009.
30. Balu Santhanam, "On a Sturm-Liouville framework for Continuous and Discrete Frequency Modulation," **Invited paper**, *Proc. of Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, pp. 1747-1751, Oct., 2009.
31. Q. Wang, M. Pepin, B. Santhanam, T. Atwood, M. M. Hayat, "SAR-based Vibration Retrieval Using the Fractional Fourier Transform in Slow Time," *Proc. of SPIE Defence and Security Symposium*, Vol. 7669, April 2010.
32. B. Santhanam, and M. Hayat, "On a Subspace Framework for Discrete Fractional Fourier Transform Based Chirp Parameter Estimation," *Proc. IEEE DSP and Education Workshop*, pp. 360-363, Jan 2011.
33. Q. Wang, B. Santhanam, M. P. Pepin, T. D. Atwood, and M. M. Hayat, "SAR vibrometry using a pseudo-subspace approach based on the discrete fractional Fourier transform," *Proc. of SPIE Conference on Defense, Security, and Sensing*, Vol. 8021, DOI: 10.1117/12.884001, June 2011.
34. Q. Wang, M. Pepin, R. Beach, R. Dunkel, T. Atwood, B. Santhanam, W. Gerstle, and M. Hayat, "Demonstration of Target Vibration Estimation in Synthetic Aperture Radar Imagery," *Proc. IGARSS*, pp. 4083-4086, July 2011.
35. D. J. Peacock and Balu Santhanam, "Multicomponent Subspace Chirp Parameter Estimation Using Discrete Fractional Fourier Analysis," *Proc., IASTED Conference on SIP-2011*, pp. 326-333, DOI: 10.2316/P.2011.759-104, Dec 14-16. 2011.
36. Q. Wang, M. Pepin, T. Atwood, A. W. Doerry, B. Santhanam, W. Gerstle, and M. M. Hayat, "Reduction of Vibration Induced Artifacts in Synthetic-Aperture-Radar Imagery Using the Fractional Fourier Transform," *Proc. ICIP 2012*, pp. 2677-2680, 2012.

37. Q. Wang, B. Santhanam, M. Pepin, M. M. Hayat, and T. Atwood, "Refocusing vibrating targets in SAR images," *Proc. SPIE 8361*, 836106, 2012.
38. Q. Wang, B. Santhanam, M. Pepin, and M. M. Hayat, "Performance Analysis on Synthetic Aperture Radar-based Vibration Estimation in Clutter," *Proceedings of ACSSC-2012*, pp.217-221, Nov. 4-7, 2012.
39. Balu Santhanam, "On a Matrix Framework for the Teager-Kaiser Energy Operator," *Proc., IEEE DSP/SP Education Workshop*, pp. 69-72, Aug., 2013.
40. D. J. Peacock, B. Santhanam, "Comparison of Discrete Fractional Fourier Transform Bases for Wideband Chirp Parameter Estimation," *Proc. IEEE DSP/SP Education Workshop*, pp. 65-68, Aug 2013.
41. O. Agcaoglu, B. Santhanam, and M. M. Hayat, "Improved Spectrograms Using the Discrete Fractional Fourier Transform," *Proc. IEEE DSP/SP Education Workshop*, pp. 80-85, Aug., 2013.
42. Adebello Jelili, Balu Santhanam, and Majeed Hayat, "Limitations and Capabilities of the Slanted Spectrogram Analysis Tool for SAR-Based Detection of Multiple Vibrating Targets," *Proc. of Asilomar Conference on Signals, Systems, and Computers*, pp. 172-176, Pacific Grove, CA, Nov. 2014.
43. J. B. Campbell, Q. Wang, J. Ade-Bello, H. Caudana, N. B. Trujillo, I. Bhatta, R. Dunkel, T. Atwood, A. Doerry, W. H. Gerstle, B. Santhanam, and M. M. Hayat, "SAR-based Vibrometry Using the Fractional Fourier Transform," *Proc. SPIE 9461, Radar Sensor Technology XIX; and Active and Passive Signatures VI*, doi: 10.1117/12.2180660, May 2015.
44. Wenjing Liu and Balu Santhanam, "Wideband-FM Demodulation for Large Wideband to Narrowband conversion factors Via Multirate Frequency Transformations," *Proc. of IEEE Signal Processing and SP Education Workshop*, pp. 97-102, Aug 2015.
45. Ishwor Bhatta and Balu Santhanam, "A Comparative Study Of Commuting Matrix Approaches For The Discrete Fractional Fourier Transform," *Proc. of IEEE DSP/SP Education Workshop*, pp. 103-108, Aug 2015.
46. Jelili Adebello and Balu Santhanam, "Clutter Suppression in Synthetic Aperture Radar Targets using the DFRFT and Subspace Methods with Rank Reduction," *Proc. of Asilomar Conference on Signals, Systems, and Computers*, pp.1669 - 1673, Nov. 2015.
47. Francisco P'erez Justin B. Campbell, Monica Jaramillo, Ralf Dunkel, Thomas Atwood, Armin Doerry, Walter H. Gerstle, Balu Santhanam and Majeed M. Hayat, "Exploiting synthetic aperture radar imagery for retrieving vibration signatures of concealed machinery," *Proc. SPIE 9829, Radar Sensor Technology XX, 982903*, May 2016.
48. Wenjing Liu and Balu Santhanam, "Fingerprint Feature Extraction and Classification Using Multirate Frequency Transformations and Wideband AM-FM Energy Demodulation," *Proc. of Asilomar Conference on Signals, Systems, and Computers*, pp. 576 - 579, Nov. 2016.
49. Chris De La Cruz and Balu Santhanam, "Joint EMD and Teager-Kaiser Energy Approach Towards Normal and Nasal Speech Analysis," *Proc. of Asilomar Conference on Signals, Systems, and Computers*, pp. 429 - 433, Nov. 2016.
50. B. Santhanam, T. S. Santhanam and S. Mandal, "On The Effects Of Windowing On The Discretization Of The Fractional Fourier Transform," *Proc. of Asilomar Conference on Signals, Systems, and Computers*, pp. 233 - 237, Nov. 2017.

Research Statement

Research Interests

My general areas of research lie in signal processing, DSP, digital communications, image processing, and information theory. These include (but not limited to) the topical areas of adaptive filtering, time-frequency analysis and representations for non-stationary signals specifically AM–FM type signals, cochannel signal separation, MAI suppression in multiuser communications, modulation type classification, and wideband FM demodulation.

– Multicomponent AM–FM Demodulation:

1. **Energy Separation and Demodulation:** Teager-Kaiser energy operator, energy separation and demodulation, energy demodulation for large deviations, energy demodulation in noise, multicomponent AM–FM signal model, multicomponent AM–FM signal separation and demodulation, matrix formulation of the Teager-Kaiser energy operator.
2. **Cochannel and Adjacent Channel Signal Separation:** cochannel-voice speaker separation, algebraic separation of mixtures of periodic signals, estimation of multiple periodicities in noise, cochannel FM-voice separation. *periodic algebraic separation and energy based demodulation* (PASED), energy demodulation of CPM signals, and component enumeration for multicomponent AM–FM signals using generalized energy operators,
3. **Application of energy operators:** to event detection and fault diagnosis. Analysis and extraction of features for the classification of hypernasality in cleft palate and lip patients using the Teager-Kaiser energy spectrum.

– AM–FM System Theoretical Foundations:

1. Sturm-Liouville framework for continuous and discrete frequency modulation, orthogonal modes of FM modulation, instantaneous frequency response.
2. Implications of SL AM–FM framework: S-L frequency modulation spectrum, S-L filter design and system theory for AM–FM waveforms.

– Discrete Fractional Fourier Transform:

1. Discrete fractional Fourier analysis: fractional Fourier transform (FRFT), discrete rotational Fourier Transform (DRFT), discrete Fractional Fourier Transform (DFRFT), time-frequency analysis of multicomponent chirp signals via the DFRFT, subspace methods for multicomponent chirp rate estimation, discrete Wigner distribution, slanted fractional spectrogram based on the DFRFT and applications, a unified framework for time-frequency analysis of non-stationary signals,
2. Applications of DFRFT analysis: time-frequency multiplexing, multicomponent signal separation, cochannel signal separation, application of the DFRFT to the estimation of velocity and acceleration of vibrating target using SAR. Subspace multicomponent chirp parameter estimation in noise using the DFRFT. Clutter suppression via subspace or Hankel rank reduction based multicomponent chirp parameter estimation.

– Wideband FM Demodulation

- * Multirate frequency transformations, wideband to narrowband conversion, bandwidth compression and noise shaping, Noble identities, adaptive linear predictive frequency tracking.
- * Applications of wideband FM demodulation: wideband formant demodulation for speech applications such as in hypernasal formant analysis, wideband FM image demodulation using the bi-directional Hilbert transform, wideband demodulation of CPM signals with both full and partial response signaling via two stage linear predictive approaches for satellite communications, reduced sampling rate requirement for digital radio frequency memory (DRFM) devices, and A/D & D/A design for very high sampling rates.

– Hybrid ICA and SVM Learning Systems:

1. Hybrid ICA and machine learning approaches for pattern classification: serial combination of the fast-ICA algorithm followed by a SVM with bootstrap. that takes a set of features and exploits the non-Gaussianity of the features to maximize the K-L divergence between the

features. The increase in negentropy between features translates to a increase in the SVM margin and a improvement in recognition performance.

2. Applications of the ICA-SVM hybrid approach: robust recognition and classification of analog and digital modulation using hybrid ICA-SVM approaches, vibration based engine type classification using hybrid ICA-SVM approaches, application of the hybrid ICA-SVM approach to feature extraction in functional magnetic resonance imaging.
- **MAI Reduction in DSSS-CDMA:** Adaptive IIR normalized lattice filtering for reduction of MAI in DSSS-CDMA systems, subspace-MOE based MAI suppression, ICA-based MAI reduction, prior ICA-based MAI suppression.

Research Collaborators

1. Steven R. J. Brueck, Director, Center for High Technology Materials, University of New Mexico, Albuquerque, email: brueck@chtm.unm.edu.
2. Vince Calhoun, Director, Medical Imaging Analysis Laboratory and Associate Professor Department of E.C.E., University New Mexico, email: vcalhoun@unm.edu.
3. Majeed Hayat, Professor, Department of E.C.E., UNM, email: hayat@ece.unm.edu
4. Ernest Armstrong, AFRL-WPAFB, Dayton, Ohio.
5. Jim McClellan, Professor, Center for Signal and Image Processing, Georgia Institute of Technology, Atlanta, Georgia, email: jim.mcclellan@ece.gatech.edu
6. Alexandros Potamianos, Associate Professor, Department of Electronics and Communication, Technical University of Crete, Crete, Greece, email: potam@telecom.tuc.gr.
7. Lucio Pessoa, Intellectual, Property Systems Technologist at Freescale Semiconductor, email: lucio.pessoa@freescale.com
8. Thalanayar S. Santhanam, Professor, Department of Physics, Saint Louis University, Saint Louis, Missouri, email: santhats@slu.edu
9. Petros Maragos, Professor, Computer Vision, Speech Communication, and Signal Processing group, National Technical University of Athens, Greece, email: maragos@cs.ntua.gr
10. Walter Gerstle, Professor, Department of Civil Engineering, University of New Mexico, email: gerstle@unm.edu.
11. Tom Quatieri, Information Systems Technology Group, MIT Lincoln Labs, email: quatieri@ll.mit.edu.

Teaching Statement

Teaching Goals and Vision

Teaching is an integral part of academic activities and professional development in today's universities. Reaching a more diverse audience of non traditional students and updating one's teaching repertoire to include modern technological and internet related tools has become a necessity, in an electronic world of cell phones, laptop computers and email, to maintain and develop a competitive curriculum. Teaching makes the university experience unique and richer, as opposed to working in a research lab where the primary focus is just on research and publications. It is my specific desire to attain that unique balance between teaching and research where these become synergistic activities. Listed below are some of my teaching accomplishments and some changes that I have incorporated into my teaching plan towards achieving the stated goals.

1. **Integrating teaching and research:** at the graduate level integrating ones research into teaching becomes essential to create a pipeline of motivated graduate students who can do independent research. As a faculty at UNM, I have been able to use the existing infrastructure to teach special topic courses in MATLAB, "statistical communication theory", "adaptive filtering," and "Space-time Array Processing". These courses provide the students with a look-ahead view of relevant research topics and facilitate a smoother transition for students into research.
2. **Mentoring undergraduate students:** this gives motivated undergraduate students an opportunity to experience signal processing and communications related problems that are of interest to the industry and the academic community. It also facilitates a pipeline of good potential graduate students. During my tenure at UNM, I have mentored several undergraduate and graduate students such as Chris Gibson (presently completing MS in Michigan), Eric Roberts, through special problems courses, during the summer semesters. These courses provided me with the opportunity to motivate some bright students to pursue a graduate degree in the SPCOM area.
3. **Technology:** this includes web-based dissemination of information and lecture notes, efficient use of technological tools such as real-audio, real-video, Java applets. Such tools provide a less paper-intensive and more information efficient teaching experience. I have found that these tools significantly enhance the appeal and utility of these courses. In addition they provide a audio-visual dimension to the signal processing and number-crunching involved.
4. **Access to non traditional students:** a significant portion of today's students are non-traditional, part time students who are employed elsewhere. Leveraging the distance learning program at UNM, I have taught courses at Los Alamos, Sandia National Labs, Intel, and Honeywell using the ITV program at UNM. Using cloud resources I post my lectures on dropbox resources to accommodate students outside of the New Mexico.
5. **Incorporating real-world examples:** this involves incorporating MATLAB based exercises and projects into the teaching of courses. This is in response to student requests over the years for more "real-world" examples. Signal processing and communications are areas where the concepts taught are abstract and tend to get mathematically intense at times and this would give the students a physical feel for the mathematical principles involved and their applications. At UNM, I introduced and taught a spring semester special topic course on "Signal Processing Exercises in MATLAB" that dealt with specific applications of signal processing and communications.
6. **Completing the pipeline:** maintaining a good network and good communication with prior students and colleagues employed both in the industry or in academia allows students who are currently in the research program to network with prospective employers. Providing students interested in a academic career with teaching opportunities in classes and guidance is also a very effective way to complete the pipeline. I specifically ask my PhD students to speak in seminars and various presentations to provide them venues and opportunities to present and discuss their research.

Teaching at UNM

Curriculum Development

- New Courses:
 1. Submitted proposal for an undergraduate course in “Engineering Problem Solving Using MATLAB,” to ECE undergraduate committee, Fall 2000.
 2. Offered special topics courses (ECE-595) in specific areas such as “Adaptive Filtering” and “Spatial Array Processing”.
 3. Offered a special topics course, ECE-495, “Signal Processing Exercises in MATLAB,” in Spring-01 and Spring 2002.
 4. Introduced course ECE-542, “Digital Communication Theory,” now a core course in the SP-COM curriculum.
- Curricular Review and Mentorship:
 1. Responsible for streamlining ECE-314 and ECE-340 to include MATLAB based instruction.
 2. Made ECE-441, introduction to communication systems, a core undergraduate class.
 3. Enhance your engineering skills (EYES) program originator and mentor.
 4. Course director for the undergraduate Signals and Systems course, ECE-314 and ECE-439, Introduction to Digital Signal Processing.
 5. Mentor for (a) several senior undergraduate students like Chris Gibson, (b) undergraduate honor’s projects with students like Solomon Rugunda, and (c) graduate students, like Eric Roberts, Hariharan, through special problems courses (ECE-551).
 6. Responsible for qualifying exam coordination of questions pertaining to the course ECE-539 and ECE-541 (along with Majeed Hayat).

Advisory Duties

Graduated Ph.D/MS Students :

1. Ryan C. Shoup, “Efficient Implementation of Linear Minimum Mean Squared Error Code Division Multiple Access Receivers Via Recursive Filtering,” Ph.D thesis, 2001, presently employed with MIT Lincoln Laboratories.
2. Eric Wu: “Optimization for Imaging Interferometric Lithography in Technology Computer-Aided Design,” Ph.D thesis, presently employed as a member of the technical staff, Spansion, San Francisco Bay Area, 2003.
3. Saeid Taheri: “Cross Layer Design of Communication Network Layers,” Ph.D thesis, 2004, presently a post-doctoral researcher, University of New Mexico.
4. Juan Gaspar Vargas Rubio: “The Centered Fractional Fourier Transform, Properties, Computation, and Application to Linear Chirp Signals,” Ph.D thesis, 2004, presently faculty, Universidad Autonoma Metropolitana Azcapotzalco, Departamento de Electronica, Mexico, DF 02200, MEXICO.
5. Thanis Mark Tridhavee, “Optimization of Frequency Parsing Strategies for Imaging Interferometric Lithography,” MS thesis, 2003, presently a Ph.D student at University of Michigan, Ann Arbor.
6. Malay Gupta, “ICA Assisted Blind Multiuser Detection in DS-CDMA Systems,” Ph.D Thesis, Nov. 2005, DSP Software Developer at Research in Motion.
7. Lakshmi puram Srikanth Reddy, M.S. thesis topic: “Multicomponent Chirp Demodulation Using the Multiangle Discrete Fractional Fourier Transform,” March 2007, software developer, Norwood promotional products, Indianapolis.
8. David Boutte, Ph.D thesis topic: “A hybrid ICA and Machine Learning Approach for Modulation Detection and Signal environment analysis,” Ph.D thesis, May 2009. currently a post-doctoral researcher at the UNM Mind Institute.

9. Daniel Jackson Peacock, MS project topic: “Multicomponent Chirp Parameter Estimation using the Discrete Fractional Fourier Transform and Subspace Decomposition,” completed May 2012, employed as a member of the technical staff at Sandia National Laboratories.
10. Oktay Agcaoglu, M. S. topic: “Improved Spectrograms Using the Discrete Fractional Fourier Transforms,” March 2013, currently a PhD student at the UNM Mind Institute.
11. Jelili Adebello, MS project topic: “Hankel rank reduction based clutter suppression for DFRFT enabled SAR vibrometry,” completed July 2015.
12. Chris De La Cruz, MS thesis topic: “Hypernasal Speech Analysis via Empirical Mode Decomposition and the Teager-Kaiser Energy Operator,” completed June 2016.
13. Wenjing Liu, Ph.D thesis topic: “Multirate frequency transformation and wideband AM–FM signal demodulation with Applications to Signal Processing and Communications,” joined Fall 2013.

Co-advisor:

- O. Lankoande, “Speckle Reduction and Segmentation of SAR Imagery Using A Markov Random Field Model,” with Prof. Majeed Hayat.

Related Departmental Service

- Member of the following ECE committees:
 1. ECE undergraduate curriculum committee (02-08).
 2. ECE graduate curriculum committee (99-00,00-01,01-02,04-05).
 3. ECE faculty search committee (00,01,02).
 4. ECE Promotion and Tenure committee, 06-07, 07-08, 08-09.
 5. Chair of ECE SPCOM faculty search committee, 05-06.
 6. ECE awards committee (99-00).
- Area chair for the signal processing and communications (SPCOM) group 00-01, 04-05, 05-06, 08-09.
- Steering committee member, EYES program for graduate recruitment, 05, 06, 07.
- Member of Dean’s dissertation award committee, 08.

Other Synergistic Activities

Professional Activity

1. DSP workshops attended:
 - Xilinx sponsored DSP Workshop on DSP Design Flow, Aug 5-6, University of New Mexico, Albuquerque, 2004.
 - Xilinx sponsored workshop on Digital Signal Processing with FPGAs, May 30-31, 2006.
 - Attended TI DSP Workshop on DSP education using TI platforms.
2. Conference Committee Membership:
 - Technical area chair for “Adaptive Systems” for the Asilomar Conference on Signals, Systems and Computers, Nov. 2004.
 - Member, International Program Committee, International Conference on Communications Systems and Applications, Banff, Canada, July, 2005 and 2006.
 - Member, International Program Committee, IEEE International Conference on Systems, Man, and Cybernetics, 2005 and 2006.
 - Technical program committee member, IEEE DSP Workshop, Sedona AZ, Jan 2011.
 - International program committee member, IASTED conference on Signal and Image Processing, Dallas, Dec, 2011.
3. Conference Session Chair:

- Session chair, Asilomar conference on Signals, Systems, and Computers, Invited Session, “Emerging Models and Methods for Image/Video Processing,” Nov 2016.
- Session chair, IEEE Vehicular Technology Conference, Las Vegas, Nevada, April 2006.
- Session chair, “Signal Representations,” IEEE DSP Workshop, Jackson Hole, Wyoming, Sep 2006.
- Session chair, “Linear Algebra, Applications, and Optimization,” ICASSP-2007, Hawaii, April 2007.
- Session chair, “Signal Representations,” IEEE DSP Workshop, Marcos Islands, Florida, Jan 2009.
- Session chair, “Speech processing I ” and ”Models for Signal and Image processing” at the Asilomar Conference on Signals, Systems, and Computers, 2009.

4. Talks given:

- Seminar talk at the CSIP, School of ECE, Atlanta, Georgia, entitled, “Discrete Gauss-Hermite Functions and Eigenvectors of the Discrete Fourier Transform,” Jan 2007.
- Seminar Talk, Los Alamos national labs, entitled ”Sturm-Liouville Framework for Continuous and Discrete Frequency Modulation,” April 2010.
- Seminar Talk, Los Alamos National Labs, entitled, “On Orthogonal Modes of Continuous and Discrete Frequency Modulation,” Aug, 2011.

5. Patents:

- Coauthor on patent US 7,961,975 B2, “System and Method for Reduction of Speckle Noise in an Image,” with Ousseini Lankoande and Majeed Hayat, issued June 14, 2011.
- Coauthor on patent US 8,814,927 B2, with Ousseini Lankoande and Majeed Hayat, issued May 22, 2012.
- Coauthor on patent US 8,208,724 B2, with Ousseini Lankoande and Majeed Hayat, issued June 16, 2012.

• Reviewer Activities:

- IEEE Student Branch Counsellor (2002-2003).
- Technical reviewer for the following journals: (1) IEEE Transactions on Signal Processing, (2) IEEE Signal Processing Letters, (3) IEEE Transactions on Communications, (4) IEEE Transactions on Image Processing, (5) IEEE Transactions on Circuits and Systems I, (6) IEEE Transactions on Automatic Control, (7) IEEE Transactions on Vehicular Technology, (8) IEEE Transactions on Circuits and Systems II, (9) Signal Processing, Elsevier Science, (10) IEEE Communication Letters, (11) IEEE Transactions on Acoustics and Speech, (12) “Optics Express,” (Optical Society of America), 2004.
- Technical reviewer for IEEE conferences in the signal processing and communications areas, such as GLOBECOM, VTC, SMC, ICASSP, and ISCAS.

References

- Professor Thomas F. Quatieri
Massachusetts Institute of Technology
Information Systems Technology Group
244 Wood Street
Lexington, MA 02420-9108
voice: 781-981-2583, Fax: 781-981-0186
email: quatieri@ll.mit.edu.
- Lucio Pessoa
Data Science Strategist, Multinformatics, LLC
Tel: (425) 749-2268 (Mobile)
Email: lpessoa@multinformatics.com
- Professor Bernard Levy
Department of ECE
University of California, Davis
Email: blevy@ucdavis.edu
Tel: (530) 752-8025, Fax: (530) 752-8428.
- Professor Scott Acton
Thornton Hall - E309
University of Virginia
Charlottesville, VA 22908
Email: acton@virginia.edu.