Jianbo Gao

Distinguished Professor, Founding Director, Institute of Complexity Science and Big Data Technology, Guangxi University, China
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EDUCATION

- Ph.D. Electrical Engineering (communications), UCLA, September, 2000
- M.S. Mechanics (fluid mechanics), Institute of Mechanics, Chinese Academy of Sciences, Beijing, China, July, 1991
- B.S. Electrical Engineering (control), Zhejiang University, Hangzhou, China, July, 1988

PROFESSIONAL EXPERIENCE

- Distinguished Professor, Director, Institute of Complexity Science and Big Data Technology, Guangxi University, China 10/2013 - present
- Adjunct Prof., BME, Xi'an Jiao-Tong Univ, China 06/2011 - present
- Full research professor, Mechanical and Materials Engineering, Wright State Univ 01/2010 - present
- Founder, PMB Intelligence LLC, Sunnyvale, CA, USA 05/2009-present
- Assistant Professor, Electrical & Computer Eng., University of Florida, Gainesville, USA 07/2002-05/2009
- Assistant Research Engineer, EE, UCLA 09/2000-06/2002
- Research Assistant, EE, UCLA, USA 8/1997-08/2000
- Research and Teaching Assistant, Atmos. Sci., UCLA, USA 9/1994-7/1997
- Research Assistant, NCAR, Boulder, Colorado, USA 7/1996-9/1996
- Assistant Professor, Lab for Nonlinear Mechanics, Inst. of Mechanics, Chinese Academy of Sciences, Beijing 7/1991-9/1994
- Visiting Scholar, State Key laboratory for Pattern Recognition, Inst. of Automation, Chinese Academy of Sciences, Beijing 1/1992-7/1992

INTERESTS

Broadly interested in developing new approaches for interdisciplinary (including bioinformatics, biomedical, electrical, mechanical, environmental, and ecological) applications by synthesizing signal/image processing techniques, information theory, control theory, statistical and large-scale optimization methods, and chaos and fractal theory.

STUDENTS and POSTDOCS SUPERVISED

Two M.S., three Ph.D students, two post-docs

PUBLICATIONS

A. Book

- J. Holden, M. Riley, J.B. Gao and K. Torre, *Fractal Analyses: Statistical and Methodological Innovations and Best Practices*. e-Book, Frontiers, 2013.
- J.B. Gao, Y.H. Cao, W.W. Tung, and J. Hu, *Multiscale Analysis of Complex Time Series — Integration of Chaos and Random Fractal Theory, and Beyond*, Wiley, August, 2007.

B. Book chapter

- J.B. Gao, J. Hu, and W.W. Tung, A unified theory for the multiscale analysis of complex time series. In *Multiscale Signal Analysis and Modeling*, Eds. X.P. Shen and A. I. Zayed, Springer, 221-231.
- J.B. Gao, Y.H. Cao, W.W. Tung, Deciphering the Structures of Genomic DNA Sequences Using Recurrence Time Statistics. In *Data Mining in Biomedicine* (Springer Series in Optimization and Its Applications), **7**, 321-337 (2007), Eds. P.M. Pardalos, V.L. Boginski, and A. Vazacopoulos.
- N.S.V. Rao, J.B. Gao, and L. Chua, On dynamics of transport protocols in wide-area Internet connections, *Complex Dynamics in Communication Networks*, G. Vattay and L. Kocarev, eds., Springer-Verlag, 2005.

C. Journal Papers (SCI citations $>$ 1500, H index 24; Google Scholar citations $>$ 3600, H index 30)

1. J. Hu and J.B. Gao, Multiscale characterization of sea clutter by scale-dependent Lyapunov exponent. Mathematical Problems in Engineering (special issue on Advanced Topics in Dynamics of Complex Systems) (in press).
2. 2. X.M. Yu, J.K. Ye, J. Hu, X.P. Liao, and J.B. Gao, Fractal behavior in the clarification process of cane sugar production Mathematical Problems in Engineering (special issue on Chaos-Fractals Theories and Applications) (in press).
3. J. Hu, Y. Zheng, and J.B. Gao, Long-range temporal correlations, multifractality, and the causal relation between neural inputs and movements. *Frontiers in Neurology*. October 2013 Volume 4 Article 158.
4. J.B. Gao and J. Hu, Fast monitoring of epileptic seizures using recurrence time statistics of electroencephalography. *Frontiers in Computational NeuroScience* October 2013 Volume 7 Article 122.
5. J.B. Gao, F.Y. Liu, J.F. Zhang, J. Hu, Y.H. Cao, Information entropy as a basic building block of complexity theory. *Entropy* 2013, 15(9), 3396-3418; doi:10.3390/e15093396.
6. J.B. Gao, Complex systems and emergence: How theory meets reality. *Advances in Mechanics*. V43, 359-389 (2013).
7. J.B. Gao and J. Hu, Financial crisis, Omori's law, and negative entropy flow. *International Review of Financial Analysis* (in press).
8. J.B. Gao, B.M. Gurbaxani, J. Hu, K.J. Heilman, V.A. Emauele, G.F. Lewis, M. Davila, E.R. Unger, J.S. Lin, Multiscale analysis of heart rate variability in nonstationary environments. *Frontiers in Computational Physiology and Medicine* (in press).
9. M. Bowers, J.B. Gao, and W.W. Tung, Long-Range Correlations in Tree Ring Chronologies of the USA: Variation Within and Across Species. *Geophysical Research Letters* (in press).

10. J.B. Gao, Q. Han, X.L. Lu, L. Yang, J. Hu, Self organized hotspots and social tomography. *Complex Systems* 2013, doi: http://eudl.eu/doi/10.4108/trans.cs.1.2.e1.

11. J.G. Holden, M.A. Riley, J.B. Gao, and K. Torre, Fractal analyses: statistical and methodological innovations and best practices. *Front Physiol.* **4**: 97 (2013). doi: 10.3389/fphys.2013.00097.

12. M.A. Riley, N. Kuznetsov, S. Bonnette, S. Wallot, J.B. Gao, A Tutorial Introduction to Adaptive Fractal Analysis. *Frontiers in Fractal Physiology* 28 September, 2012 doi: 10.3389/fphys.2012.00371.

13. N. Kuznetsov, S. Bonnette, J.B. Gao, M.A. Riley, Adaptive fractal analysis reveals limits to fractal scaling in center of pressure trajectories, *Annals of Biomedical Engineering*, 2012, DOI 10.1007/s10439-012-0646-9.

14. M.C. Bowers, W.W. Tung, J.B. Gao, On the distributions of seasonal river flows: lognormal or power-law? *Water Resources Research* VOL. 48, W05536, doi:10.1029/2011WR011308, 2012.

15. J.B. Gao, J. Hu, X. Mao, M. Perc, Culturomics meets random fractal theory: Insights into long-range correlations of social and natural phenomena over the past two centuries. *J. Royal Society Interface*, 2012, doi:10.1098/rsif.2011.0846.

16. J.B. Gao, J. Hu, W.W. Tung, E. Blasch, Multiscale analysis of physiological data by scale-dependent Lyapunov exponent. *Frontiers in Fractal Physiology* January 2012, doi: 10.3389/fphys.2011.00110..

17. J.B. Gao, J. Hu, W.W. Tung, Entropy measures for biological signal analysis. *Nonlinear Dynamics* **68**, 431-444. DOI 10.1007/s11071-011-0281-2 (2012).

18. J.B. Gao, J.Hu, X. Mao, and W.W. Tung, Detecting low-dimensional chaos by the "noise titration" technique: possible problems and remedies. *Chaos, Solitons, & Fractals* **45**, 213 - 223 (2012) .

19. J.B. Gao, J. Hu, X. Mao, M. Zhou, B. Gurbaxani, J.W.-B. Lin, Entropies of negative incomes, Pareto-distributed loss, and financial crises. *PLoS ONE* **6**(10): e25053. doi:10.1371/journal.pone.0025053 (2011).

20. J.B. Gao, J. Hu, T. Buckley, K. White, C. Hass, Shannon and Renyi Entropies To Classify Effects of Mild Traumatic Brain Injury on Postural Sway. *PLoS ONE* **6**(9): e24446. doi:10.1371/journal.pone.0024446 (2011).

21. J.B. Gao, J. Hu, W.W. Tung, Facilitating joint chaos and fractal analysis of biosignals through nonlinear adaptive filtering. *PLoS ONE* **6**(9): e24331. doi:10.1371/journal.pone.0024331 (2011).

22. J.B. Gao, J.Hu, W.W. Tung, and Y. Zheng, Multiscale analysis of economic time series by scale-dependent Lyapunov exponent. *Quantitative Finance* DOI:10.1080/14697688.2011.580774 (2013).

23. J.B. Gao, J.Hu, and W.W. Tung, Complexity measures of brain wave dynamics, *Cognitive Neurodynamics* **5**, 171-182 (2011).

24. W.W. Tung, J.B. Gao, J. Hu, L. Yang, Recovering chaotic signals in heavy noise environments. *Phys. Rev. E* **83**, 046210 (2011).

25. M.Q. Jiang, Z. Ling, J.X. Meng, J.B. Gao, L.H. Dai, Nanoscale periodic corrugation to dimple transition due to "beat" in a bulk metallic glass *Scripta Materialia* **62** (8), 572 - 575.

26. M.Q. Jiang, J.X. Meng, J.B. Gao, X.L. Wang, T. Rouxel, V. Keryvin, Z. Ling, L.H. Dai, Fractal in fracture of bulk metallic glass, *Intermetallics* **18**, 2468-2471 (2010).

27. J.B. Gao, H. Sult an, J. Hu, and W.W. Tung, Denoising nonlinear time series by adaptive filtering and wavelet shrinkage: a comparison. *IEEE Signal Processing Letters* **17**, 237-240 (2010).

28. J. Hu, J.B. Gao, W.W. Tung, and Y.H. Cao, Multiscale analysis of heart rate variability: a comparison of different complexity measures. *Annals of Biomedical Engineering* **38**, 854-864 (2010).

29. J.B. Gao, W.W. Tung, and J. Hu, Quantifying dynamical predictability: the pseudo-ensemble approach (in honor of Professor Andrew Majda's 60th birthday) *Chinese Annals. Math.* Series B **30**, 569-588 (2009).

30. J. Hu, J.B. Gao, and W.W. Tung, Characterizing heart rate variability by scale-dependent Lyapunov exponent, *Chaos* (special issue on *Controversial Topics in Nonlinear Science: Is the Normal Heart Rate Chaotic?*; it is one of the most downloaded papers in that issue) **19**, 028506 (2009).

31. J. Hu, J.B. Gao, and X.S. Wang, Multifractal analysis of sunspot time series: the effects of the 11-year cycle and Fourier truncation, *J. Statistical Mech.* 2009/02/P02066.

32. J. Hu, W.W. Tung, and J.B. Gao, A new way to model non-stationary sea clutter, *IEEE Signal Processing Letters* **16**, 129-132 (2009).

33. W.W. Tung, J. Hu, J.B. Gao, and V.J. Billock, Diffusion, Intermittency, and Noise-sustained Metastable Chaos in the Lorenz Equations: Effects of noise on multistability. *Int. J. Bifurcations & Chaos* (theme issue Multistability in Dynamical Systems) **18**, 1749-1758 (2008).

34. J. Hu, J.M. Lee, J.B. Gao, K.D. White, and B. Crosson, Assessing a signal model and identifying brain activity from fMRI data by a detrending-based fractal analysis. *Brain Structure and Function*, **212**, 417-426 (2008).

35. J.M. Lee, J. Hu, J.B. Gao, B. Crosson, K.K. Peck, C.E. Wierenga, K.M. McGregor, Q. Zhao, and K.D. White, Discriminating brain activity from task-related artifacts in functional MRI: Fractal scaling analysis simulation and application. *NeuroImage*, **40**, 197-212 (2008).

36. J. Hu, J.B. Gao, Y.H. Cao, E. Bottinger, and W.J. Zhang, Exploiting noise in array CGH data to improve detection of DNA copy number change. *Nucleic Acids Research* **35**, e35 (2007).

37. J. Hu, J.B. Gao, and J.C. Principe, Analysis of biomedical signals by the Lempel-Ziv complexity: the effect of finite data size. *IEEE Trans. on Biomedical Engineering* **53** 2606-2609, (2006).

38. J.B. Gao, J. Hu, W.W. Tung, Y.H. Cao, Distinguishing chaos from noise by scale-dependent Lyapunov exponent. *Phys. Rev. E* **74**, 066204 (2006).

39. J. Hu, J.B. Gao, F.L. Posner, Y. Zheng, and W.W. Tung, Target detection within sea clutter: a comparative study by fractal scaling analyses. *Fractals* **14**, 187-204 (2006).

40. X.S. Wang, J. Hu and J.B. Gao, Nonlinear dynamics of regenerative cutting processes - comparison of two models. *Chaos, Solitons, & Fractals* **29**, 12191228 (2006).

41. J.B. Gao, V.A. Billock, I. Merk, W.W. Tung, K.D. White, J.G. Harris, V.P. Roychowdhury, Inertia and memory in ambiguous visual perception, *Cognitive Processing* **7**, 105-112 (2006).

42. J.B. Gao, J. Hu, W.W. Tung, Y.H. Cao, N. Sarshar, V. P. Roychowdhury, Assessment of long range correlation in time series: How to avoid pitfalls. *Phys. Rev. E* **73**, 016117 (2006).

43. J. Hu, W.W. Tung, and J.B. Gao, Detection of low observable targets within sea clutter by structure function based multifractal analysis. IEEE Trans. *Antennas & Propagation* **54**, 135-143 (2006).

44. J. Hu, W.W. Tung, J.B. Gao, Y.H. Cao, Reliability of the 0-1 test for chaos, *Phys. Rev. E* **72**, 056207 (2005).

45. J.B. Gao, Y.H. Cao, Y. Qi, and J. Hu, Building innovative representations of DNA sequences to facilitate gene finding, *IEEE Intelligent Systems* Nov/Dec, 34-39 (2005) (special issue on Data Mining for Bioinformatics).

46. Y. Zheng, J.B. Gao, J.C. Sanchez, J.C. Principe, and M.S. Okun, Multiplicative multifractal modeling and discrimination of human neuronal activity. *Phys. Lett. A* **344**, 253-264 (2005).

47. J.B. Gao, N.S.V. Rao, J. Hu, and A. Jing, Quasi-periodic route to chaos in the dynamics of Internet transport protocols. *Phys. Rev. Lett.* **94**, 198702 (2005).

48. J. Han, J.B. Gao, Y. Qi, P. Jonker, and J.A.S. Fortes, Towards hardware-redundant fault-tolerant logic for nanoelectronics. *IEEE Design & Test of Computers* (special issue) **22**, 328-339 (2005).

49. J.B. Gao, W.W. Tung, Y.H. Cao, J. Hu, and Y. Qi, Power-law sensitivity to initial conditions in atime series with applications to epileptic seizure detection. *Physica A 353*, 613-624 (2005).

50. J.B. Gao, Y. Qi, and J.A.B. Fortes, Bifurcations and Fundamental Error Bounds for Fault-Tolerant Computations. *IEEE Tran. Nanotech 4*, 395-402 (2005).

51. Y.H. Cao, W.W. Tung, J.B. Gao, and Y. Qi, Recurrence time statistics: Versatile tools for genomic DNA sequence analysis. *Journal of Bioinformatics and Computational Biology* **3**, 677-696 (2005).

52. Y. Qi, J.B. Gao, and J.A.B. Fortes, "Markov Chain and probabilistic computation: A General Framework for Fault-Tolerant System Architectures for Nanoelectronics", *IEEE Tran. Nanotech* **4**, 194-205 (2005).

53. Yinhe Cao, Wen-wen Tung, J.B. Gao, V.A. Protopopescu, and L.M. Hively, Detecting dynamical changes in time series using the permutation entropy. *Phys. Rev. E* **70**, 046217 (2004) (selected for the November 1, 2004 issue of Virtual Journal of Biological Physics Research: http://www.vjbio.org).

54. J.B. Gao and N.S.V. Rao, "Complicated Dynamics of Internet Transport Protocols", *IEEE Commun. Lett* **9**, 4-6 (2005).

55. Jianbo Gao, Yan Qi, Yinhe Cao, and Wen-wen Tung, "Protein coding sequence identification by simultaneously characterizing the periodic and random features of DNA sequences", Special issue, *Journal of biomedicine and biotechnology* **2005**, issue 2, 139-146 (2005).

56. W.W. Tung, Y. Qi, J.B. Gao, Y.H. Cao, and L. Billings, Direct characterization of chaotic and stochastic dynamics in a population model with strong periodicity. *Chaos, Solitons, & Fractals* **24** 645-652 (2005).

57. Y.H. Zhou, J.B. Gao, K.D. White, I. Merk, and K. Yao, Perceptual Dominance Time Distributions in Multistable Visual Perception. *Biological Cybernetics* **90**, 256-263 (2004).

58. J.B. Gao, Analysis of Amplitude and Frequency Variations of Essential and Parkinsonian Tremors. *Medical and Biological Engineering and Computing* **52**, 345-349 (2004).

59. W.W. Tung, M.W. Moncrief, and J.B. Gao, A systemic view of the multiscale tropical deep convective variability over the tropical western-Pacific warm pool. *J. Climate* **17**, 2736-2751 (2004).

60. Jing Hu, J.B. Gao, and K.D. White, Estimating measurement noise in a time series by exploiting nonstationarity. *Chaos, Solitons, & Fractals* **22**, 807-819 (2004).

61. J.B. Gao, Yinhe Cao, Lingyun Gu, J.G. Harris, and J.C. Principe, Detection of Weak Transitions in Signal Dynamics Using Recurrence Time Statistics, *Phys. Lett. A*, **317**, 64-72 (2003).

62. J.B. Gao, Yinhe Cao, and Jae-Min Lee, Principal Component Analysis of $1/f^{\alpha}$ Noise, *Phys. Lett. A*, **314**, 392-400 (2003).

63. J.B. Gao and I. Rubin, "Analysis of Random Access Protocol under Long-Range-Dependent Traffic", *IEEE Tran. on Vehicular Tech.*, V52, No.3, 693-700 (2003).

64. J.B. Gao, Wen-wen Tung, and Nageswara Rao, Noise Induced Hopf Bifurcation-like Sequence to Chaos in the Lorenz Equations, *Phys. Rev. Lett.*, **89**, 254101 (2002).

65. J.B. Gao and W.W. Tung, "Pathological tremors as diffusional processes", *Biological Cybernetics*, **86**, 263-270 (2002).

66. J.B. Gao and I. Rubin, Multiplicative multifractal modeling of Long-Range-Dependent network traffic, *Int. J. Comm. Systems*, **14**, 783-201 (2001).

67. J.B. Gao and I. Rubin, "Multiplicative Multifractal Modeling of Long-Range-Dependent (LRD) Traffic in Computer Communications Networks", *Nonlinear Analysis*, **47**, 5765-5774 (2001).

68. J.B. Gao and I. Rubin, Multifractal modeling of counting processes of Long-Range-Dependent network Traffic, *Computer Communications*, **24**, 1400-1410 (2001).

69. J.B. Gao, "Detecting nonstationarity and state transitions in a time series", *Phys. Rev. E*, **63**, 066202-1-8 (2001).

70. J.B. Gao and I. Rubin, "Analysis of Random Access Protocol under Bursty Traffic", *Lect Notes Comput Sci*, **2216** 71-84 (2001).

71. J.B. Gao and H.Q. Cai, On the structures and quantification of recurrence plots. *Phys. Lett. A*, **270**, 75-87 (2000).

72. J.B. Gao and I. Rubin, "Superposition of multiplicative multifractal traffic processes", *Electronics Lett.*, **36**: 761-762 (2000).

73. J.B. Gao and I. Rubin, "Multifractal analysis and modeling of VBR video traffic", *Electronics Lett.*, **36**: 278-279 (2000).

74. J.B. Gao and I. Rubin, "Statistical Properties of Multiplicative Multifractal Processes in Modeling Telecommunications Traffic Streams", *Electronics Lett.*, **36**, 101 (2000).

75. K. Hwang, J.B. Gao, J.M. Liu, "Noise-induced chaos in an optically injected semiconductor laser", *Phys. Rev. E*, **61**: 5162-5170 (2000).

76. J.B. Gao, C.C. Chen, S.K. Hwang, and J.M. Liu (invited paper), "Noise-Induced Chaos", *Int. J. Mod. Phys. B*, **13**, 3283 (1999).

77. J.B. Gao, Recurrence time statistics for chaotic systems and their applications, *Phys. Rev. Lett.*, **83**, 3178 (1999).

78. J.B. Gao, S.K. Hwang, and J.M. Liu, When can noise induce chaos?, *Phys. Rev. Lett.*, **82**, 1132 (1999).

79. J.B. Gao, S.K. Hwang, and J.M. Liu, "Effects of intrinsic spontaneous- emission noise on the nonlinear dynamics of an optically injected semiconductor laser", *Phys. Rev. A*, **59**, 1582 (1999).

80. S. Legg, J. McWilliams and J.B. Gao, Localization of deep ocean convection by a mesoscale eddy, *J. Phys. Oceanography*, **28**, 944 (1998).

81. J.B. Gao, Recognizing randomness in a time series, *Physica D*, **106**, 49 (1997).

82. J.B. Gao and Z.M. Zheng, Direct dynamical test for deterministic chaos and optimal embedding of a chaotic time series, *Phys. Rev. E*, **49**, 3807 (1994).

83. J.B. Gao and Z.M. Zheng, Direct dynamical test for deterministic chaos, *Europhys. Lett.*, **25**, 485 (1994).

84. J.B. Gao and Z.M. Zheng, Local exponential divergence plot and optimal embedding of a chaotic time series, *Phys. Lett. A*, **181**, 153 (1993).

85. Z.B. Lin, X. Er, J.B. Gao, A study on the chaotic motion in the low Reynolds number wake behind a cylinder. Science in China (Series A) **23**, 277 (1993).

D. Recent Conference Papers

1. J.B. Gao, K. Leetaru, J. Hu, C. Cioffi-Revilla, P. Schrodt, Massive media event data analysis to assess world-wide political conflict and instability. The 2013 International Conference on Social Computing, Behavioral-Cultural Modeling, & Prediction (SBP 2013), April 2-5, 2013, Washington, D.C.

2. J.B. Gao, J. Hu, Financial crisis, Omori's law, and negative entropy flow, SBP 2013, April 2-5, 2013, Washington, D.C.

3. J.B. Gao, Q. Chen, E. Blasch, Image denoising in the presence of non-Gaussian, power-law noise. IEEE NAECON, Dayton, OH, USA, 25-27, July, 2012.

4. J.B. Gao, E. Blasch, Quantitative culturomics using random fractal theory. IEEE NAECON, Dayton, OH, USA, 25-27, July, 2012.

5. J.B. Gao, W.W. Tung, E. Blasch, Multiscale analysis to facilitate joint chaos and fractal analysis of biosignals. IEEE NAECON, Dayton, OH, USA, 25-27, July, 2012.

6. J.B. Gao, J. Hu, E. Blasch, Defending against Internet worms using phase space and recurrence time methods from chaos theory. IEEE NAECON, Dayton, OH, USA, 25-27, July, 2012.

7. E. Blasch, J.B. Gao, W.W. Tung, Chaos-based Image Assessment for THz Imagery. ISSPA, Montreal (Quebec), Canada, 3-5, July, 2012.

8. J.B. Gao, Y.Zheng, J. Hu, Long-range temporal correlations, multifractality, and the causal relation between neural inputs and movements, Proceedings of the 4th Annual Dynamic Systems and Control Conference (DSCC'11), Arlington, VA, USA, Oct 31 - Nov 2, 2011.

9. J.B. Gao, J. Hu, W.W. Tung, Facilitating joint chaos and fractal analysis of biosignals through nonlinear adaptive filtering, DSCC'11, Arlington, VA, USA, Oct 31 - Nov 2, 2011.

10. J.B. Gao, J. Hu, W.W. Tung, Multiscale Analysis of Biological Signals, DSCC'11, Arlington, VA, USA, Oct 31 - Nov 2, 2011.

11. J.B. Gao, J. Hu, Fast monitoring of epileptic seizures based on recurrence time analysis of EEGs, DSCC'11, Arlington, VA, USA, Oct 31 - Nov 2, 2011.

12. YC Wang, J Gao, WW Tung, On the multiscale dynamics of tropical rainfall. 14th Conference on Mesoscale Processes

13. J.B. Gao, J. Hu, W.W. Tung, Nonlinear adaptive detrending, denoising, and decomposition of complex multiscale signals. 16th US National Congress on Theoretical and Applied Mechanics (USNCTAM), June 27 - July 2, 2010, Pennsylvania State University in University Park, PA.

14. J.B. Gao, J. Hu, W.W. Tung, Multiscale Analysis of Biological Signals. 16th USNCTAM.

15. J.B. Gao, J. Hu, T. Buckley, K. White, C. Hass, Classifying the Effects of Mild Traumatic Brain Injury on Postural Sway by Scale-Dependent Lyapunov Exponent. 16th USNCTAM.

16. J.B. Gao, Long-Range Temporal Correlations, Multifractality, and the Causal Relation Between Neural Inputs and Movements. 16th USNCTAM.

17. J.B. Gao, H.B. Dong, F. Schauer, J. Hoke, Understanding the nonlinear dynamics of cycle-to-cycle combustion variability, DCASS (Dayton-Cincinnati AIAA), March 6, 2010.

18. J.B. Gao, H.B. Dong, Z. Gaston, Exploiting dragonfly and damselfly's complex flight trajectory for quad-winged MAVs. DCASS (Dayton-Cincinnati AIAA), March 6, 2010.

19. J. Hu, W.W. Tung, J.B. Gao, E. Blasch, G.S. Chen, Multiscale modeling of sea clutter to facilitate detection of low observable targets within sea clutter, SPIE Defense & Security Symposium, April 13-17, 2009, Orlando, FL.

20. J.B. Gao, J.Hu, X.S. Wang, W.W. Tung, J.C. Principe, J.C. Sackellares, Real-time monitoring of epileptic seizures through recurrence time analysis of EEGs. The 2nd International Conference on Bioinformatics and Biomedical Engineering (ICBBE2008), May 16-18, Shanghai, China.

21. J.Hu, J.B. Gao, W.W. Tung, X.S. Wang, Y.H. Hu, Y.H. Cao, Distinguishing healthy subjects from patients with congestive heart failure using scale-dependent Lyapunov exponent. The 2nd International Conference on Bioinformatics and Biomedical Engineering (ICBBE2008), May 16-18, Shanghai, China.

22. W.W. Tung, J.Hu, J.B. Gao, R. S. Lynch, and G.S. Chen, On modeling sea clutter by noisy chaotic dynamics, SPIE Defense & Security Symposium, March 16-20, 2008, Orlando, FL.

23. J.Hu, W.W. Tung, J.B. Gao, R. S. Lynch, and G.S. Chen, On modeling sea clutter by diffusive models, SPIE Defense & Security Symposium, March 16-20, 2008, Orlando, FL.

24. J. Hu, J.B. Gao, R. S. Lynch, and G.S. Chen, Multiscale modeling approach for detecting low observable targets within sea clutter. *Proc. of IEEE Aerospace Conference* March 2008, Big Sky, Montana.

25. J. Hu, J.B. Gao, and N.S.V. Rao, Defending against Internet worms using a phase space method from chaos theory. SPIE Defense & Security Symposium, April 9-13, 2007, Orlando, FL, USA.

26. J. Hu, J.B. Gao, Y.H. Cao, and W.J. Zhang, Detection of gene copy number change in array CGH data. IEEE/NLM LSSA06, July 13-14, 2006, Bethesda, MD, USA.

27. J. Hu, J.B. Gao, and Y.H. Cao, Multiscale analysis of heart rate variability. IEEE/NLM LSSA06, July 13-14, 2006, Bethesda, MD, USA.

28. J. Hu, J.M. Lee, J.B. Gao, K.D. White, and B. Crosson, Identification of brain activity from fMRI data: comparison of three fractal scaling analyses. IEEE/NLM LSSA06, July 13-14, 2006, Bethesda, MD, USA.

29. J.M. Lee, Q. Zhao, J.B. Gao, and K.D. White, "fMRI quality assurance using phase space reconstruction of SmartPhantom simulation of BOLD contrast", *International Society for Magnetic Resonance in Medicine (ISMRM)* 14th Scientific Meeting & Exhibition, 6-12 May, 2006, Seattle, Washington, USA.

30. J. Hu and J.B. Gao, "Modeling sea clutter as a nonstationary and nonextensive random process", *IEEE 2006 International Radar Conference*, April 24-27, 2006, Verona, NY USA.

31. J. Han, E. Taylor, J. Gao and J.A.B. Fortes, Reliability Modeling of Nanoelectronic Circuits, *Proc. IEEE-NANO 2005*, IEEE Conference on Nanotechnology, July, 2005, Nagoya, Japan.

32. J. Han, E. Taylor, J. Gao and J.A.B. Fortes, Faults, Error Bounds and Reliability of Nanoelectronic Circuits, *Proc. IEEE ASAP 2005*, IEEE 16th International Conference on Application-specific Systems, Architectures and Processors, July 23-25, 2005, Samos, Greece.

33. X.S. Wang, J. Hu and J.B. Gao, Nonlinear Dynamics of Regenerative Cutting Processes - Comparison of Two Models. *Int. Conf. on Control & Auto.*, June 27-28, 2005, Budapest, Hungary, pp. 667-672.

34. J.B. Gao, Y.H. Cao, and J. Hu, "Recurrence Time Distribution, Renyi Entropy, and Pattern Discovery", Conference on Information Sciences and Systems (CISS'05), Johns Hopkins University, Baltimore, MD, March 16-18, 2005.

35. J.B. Gao, J. Hu, Y.H. Cao, Y. Qi, and Wen-wen Tung, "Large scale signal and information processing by simultaneous characterization of randomness and structures", Conference on Information Sciences and Systems (CISS'05), Johns Hopkins University, Baltimore, MD, March 16-18, 2005.

36. J.M. Lee, J. Hu, J.B. Gao, K.D. White, B. Crosson, C. Wierenga, K. McGregor, and K.K. Peck, "Identification of brain activity by fractal scaling analysis of functional MRI Data", ICASSP'05, March 18-23, 2005, Philadelphia, PA, USA.

37. J. Hu, J.B. Gao, K. Yao and U.S. Kim, "Detection of low observable targets within sea clutter by structure function based multifractal analysis", ICASSP'05, March 18-23, 2005, Philadelphia, PA, USA.

38. Y. Zheng, J.B. Gao, K. Yao, "Multiplicative Multifractal Modeling of Sea Clutter for Object Detection", IEEE 2005 International Radar Conference, May 9-12, 2005, Arlington, Virginia, USA.

39. J. Hu, J.B. Gao, and K. Yao, "Power-Law Sensitivity to Initial Conditions in Sea Clutter" IEEE 2005 International Radar Conference, May 9-12, 2005, Arlington, Virginia, USA.

40. J.B. Gao, Y. Qi, Y.H. Cao, and W.W. Tung, "Novel unsupervised methods for identifying protein coding sequence from genomic DNA sequences" Conference on Systems Analysis, Data Mining and Optimization in Biomedicine, February 2-4, 2005, University of Florida, Gainesville, FL, USA.

41. K. Yao and J.B. Gao, "Two Statistical Methods for Modeling Wireless Fading and Radar Sea Clutter Phenomena", to be presented at *Conference of Mathematics in Signal Processing VI*, the Institute of Mathematics and its applications (IMA), 14 - 16 December 2004, UK.

42. W Tung, MW Moncrieff, J Gao, A systemic analysis of multiscale convective variability in the tropics. 26th Conference on Hurricanes and Tropical Meteorology, 2004.

43. H Liu, KE Hild, JB Gao, D Erdogmus, JC Prncipe, JC Sackellares, Evaluation of a BSS algorithm for artifacts rejection in epileptic seizure detection *Proceedings of the 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS 2004)*, San Francisco, CA, September 1-5, 2004.

44. H. Liu, J. B. Gao, K. E. Hild, J.C. Principe, J. C. Sackellares, "Epileptic Seizure Detection from ECoG Using Recurrence time Statistics", *Proceedings of the 26th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS 2004)*, San Francisco, CA, September 1-5, 2004.

45. Y.H. Cao, W.-w. Tung, and J.B. Gao, "Recurrence time statistics: Versatile tools for genomic DNA sequence analysis", *The Computational Systems Bioinformatics Conference* (CSB2004), Stanford, CA, August 16-19, 2004.

46. Yan Qi, Jianbo Gao, Yinhe Cao, and Wen-wen Tung, Deriving a novel codon index by combining period-3 and fractal features of DNA sequences, *The Computational Systems Bioinformatics Conference* (CSB2004), Stanford, CA, August 16-19, 2004.

47. Jianbo Gao, Jesse Bridgewater, and Vwani P. Roychowdhury Synchronized Oscillations and Chaos in Coupled Genetic Repressilators, *The Computational Systems Bioinformatics Conference* (CSB2004), Stanford, CA, August 16-19, 2004.

48. J.B. Gao, Y.H. Cao, and W.-w. Tung, "Multifractal and recurrence time based methods for DNA sequence analysis", *Conference on Data Mining in Biomedicine*, February 16-18, 2004, University of Florida, Gainesville, FL.

49. J.B. Gao and Y.H. Cao, "Novel nonlinear methods for genomic DNA sequence analysis", poster in *Sixth Annual Winter Workshop: Data Mining, Statistical Learning, and Bioinformatics*, January 8-10, 2004, University of Florida, Gainesville, FL.

50. WW Tung, JB Gao, Multifractal features of deep convection over the tropical western pacific. EGS-AGU-EUG Joint Assembly 1, 710, 2003.

51. K.D. White, J.B. Gao, and Y.H. Zhou, "Fractal statistics of perceptual switching time series", *Vision Science and Society Conference 2003*, May 9-14, Sarasota, FL, USA (abstract appeared in *J. Vision*).

52. A. Hegde, D. Erdogmus, Y. Rao, J. Principe, J.B. Gao, "SOM-based similarity index measure:Quantifying interactions between multivariate structures," *2003 IEEE Intl. Work. on Neural Networks for Signal Processing*, September 17-19, 2003, Toulouse, France.

53. L.Y. Gu, J.B.Gao, and J. Harris, "Speech Endpoint detection in noisy environments using a Poincare recurrence metric", *ICASSP 2003*, Hong Kang, April.

54. J.B. Gao and W.W. Tung, The nature of essential and Parkinsonian tremors, *The 7th Experimental Chaos Conference*, San Diego, USA, August 25-29, 2002.

55. J.B. Gao, S.K. Hwang, H.F. Chen, Z. Kang, K. Yao, and J.M. Liu, "Can sea clutter and indoor radio propagation be modeled as strange attractors?" *The 7th Experimental Chaos Conference*, San Diego, USA, August 25-29, 2002.

56. J.B. Gao and I. Rubin, "Performance of Random Multiple Access Scheme Under Long-Range-Dependent Traffic", *ICC'2002*, New York, April, 2002.

57. J.B. Gao and k. Yao, "Multifractal features of sea clutter", *IEEE Radar Conference 2002*, Long Beach, CA, April, 2002.

58. J.B. Gao and I. Rubin, "Analysis of Random Access Protocol under Bursty Traffic", *IFIP/IEEE International Conference on Management of Multimedia Networks and Services 2001*, Chicago IL, Oct., 2001.

59. J.B. Gao, V. P. Roychowdhury, R. Ritke, and I. Rubin, "IP Packet Level vBNS Traffic Analysis and Modeling", *SPECTS'01*, Orlando, Florida, July, 2001.

60. J.B. Gao and R. Ritke, "Long-Range-Dependence Properties and Multifractal Modeling of vBNS traffic", *Applied Telecommunications Symposium (ATS'01)*, Seattle, Washington, April, 2001.

61. J.B. Gao and I. Rubin, "Multiplicative Multifractal Modeling of Long-Range-Dependent (LRD) Traffic in Computer Communications Networks". *World Congress of Nonlinear Analysts*, July, 2000, Catonia, Sicily, Italy.

62. J.B. Gao and I. Rubin, "Superposition of Multiplicative Multifractal Traffic Streams". *ICC2000*, June, 2000, New Orleans, Louisiana.

63. J.B. Gao and I. Rubin, "Multifractal modeling of counting processes of Long-Range Dependent network traffic". *Proceedings SCS Advanced Simulation Technologies Conference*, San Diego, CA, 1999.

64. J.B. Gao and I. Rubin, "Multiplicative Multifractal Modeling of Long-Range-Dependent Traffic". *Proceedings ICC'99*, Vancouver, Canada, June, 1999.

65. J.B. Gao, Modes interactions in wakes behind a cylinder. *Int. Conf. on Fluid Mech. and Theo. Phys. in Honor of Prof. Pei-Yuan Chou's 90th Anniversary*, Beijing, China, June, 1992.

66. J.B. Gao, Characterizing the chaotic motion in wakes behind a cylinder. *Second Int. Conf. on Fluid Mech.*, Beijing, China, July, 1993.

67. G.W. He and J.B. Gao, A coupled map lattice model for open flow. *Second Int. Conf. on Fluid Mech.*, Beijing, China, July, 1993.

68. J.B. Gao, On the chaotic features of normal electrocardiosignal. *Second Far east Int. Conf. on Medicine and Bioengineering*, Beijing, China, August, 1993.

(CHINESE) PATENT

Crouching, gravity-driven circulating water tunnel with low turbulence level (with Z.B. Lin, et al.).

HONORS

- Sept. '93: outstanding young scientist award, Chinese Academy of Sciences.
- Marquis Who's who, 2002
- Winner of Grand Challenge in Teraheartz (THz) image processing, IEEE NAECON 2012 (with E. Blasch) — *This is a novel application of my SDLE for multiscale image processing*.

INVITED TALKS

1. "Massive media event data analysis to assess world-wide political conflict and instability", Lipari School on Computational Social Science, July 20 - July 27, 2013, Lipari Island, Italy.
2. "Complex systems and emergence: how theory meets reality" and 16 other seminars, June - August, 2013, Guangxi University.
3. "Complex systems and emergence: theory meets reality" and 7 other seminars, April - May, 2013, Chinese Academy of Sciences, Beijing Institute of Technology, Central Party School, etc.
4. "Complexities of heart rate variability in patients with chronic fatigue syndrome", Dept of Biomedical Engineering, Xian Jiao Tong Univ, China, Oct 11, 2012.
5. "Facilitating joint chaos and fractal analysis of biosignals", Dept of Biomedical Engineering, Xian Jiao Tong Univ, China, Oct 10, 2012.
6. "Mathematical modeling of biological systems: recent trends and perspectives", Dept of Biomedical Engineering, Xian Jiao Tong Univ, China, Oct 9, 2012.
7. "Ubiquity of fractal behavior and use and misuse of fractal approaches in biosignal analyses", Dept of Biomedical Engineering, Xian Jiao Tong Univ, China, Oct 8, 2012.
8. "Multiscale analysis and modeling of biological data", Dept. of Statistics, Purdue Univ., Feb. 3, 2012.
9. "Facilitating health monitoring of bio- and mechanical systems through multiscale analyses", Dept. of Mechanical Engineering, Shanghai JiaoTong Univ., May 30, 2011.
10. "Multiscale analyses of biological signals", Dept. of Biomedical Engineering, Xi'an JiaoTong Univ., May 23, 2011.
11. "Multiscale analyses of biological signals", Dept. of Psychology, Univ. of Cincinnati, May 13, 2011.
12. "Dynamical multiscale approaches for mechanics and materials science", Institute of Mechanics, Chinese Academy of Sciences, Beijing, China, November 5, 2009.
13. "Detrending, denoising, and prediction of geophysical processes", Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China, November 4, 2009.
14. "Solving massively-distributed engineering problems using nonlinear dynamics and multiscale techniques", College of Mechanical Engineering, SouthEast University, China, October 21, 2009.
15. "Solving massively-distributed engineering problems using nonlinear dynamics and multiscale techniques", National Cheng-Kung University, Taiwan, October 9, 2009.
16. "Multiscale modeling of biological data", National Yang-Ming University, Taiwan, October 7, 2009.
17. "Multiscale modeling of geophysical processes", Division of Geological and Planetary Sciences, California Institute of Technology, July 21, 2009.

18. "Detrending, denoising, and prediction of geophysical processes", Jet Propulsion Laboratory (JPL), July 15, 2009.

19. "Quantifying information loss in ensemble forecasting of dynamical systems", Department of Mathematics, Fudan University, Jan. 21, 2009 (in honor of Prof. Andrew Majda's 60th Birthday).

20. "Solving massively-distributed engineering problems using nonlinear dynamics and multiscale techniques", Institute of Mechanics, Chinese Academy of Sciences, May, 23, 2008.

21. "Multiscale analysis of complicated time series: Recent advancements", Institute of Acoustics, Chinese Academy of Sciences, May, 22, 2008.

22. "Quantifying dynamical predictability: the pseudo ensemble approach", Meteorological Bureau of Shanghai, China, May, 19, 2008.

23. " Multiscale analysis of ECG and HRV", US Army Institute of Surgical Research (USAISR), April, 23, 2008.

24. "Multiscale analysis of biological signals", Centers for Disease Control and Prevention (CDC), April, 16, 2008.

25. "Solving massively-distributed engineering problems using nonlinear dynamics and multiscale techniques", GaTech, ECE, April, 15, 2008.

26. "Quantifying dynamical predictability: the pseudo-ensemble approach", Dept. of Geophysics, Univ. of Chicago, Oct. 4, 2007.

27. "Solving massively-distributed engineering problems using nonlinear dynamics and multiscale techniques", Argonne National Laboratory, July 18, 2007.

28. "Image processing for automated crack detection on pavements", State Materials Office, Florida Department of Transportation, April 19, 2007.

29. "Multiscale Analysis of Complex Time Series by Scale Dependent Lyapunov Exponent", Courant Inst. of Mathematics, New York University, November 10, 2006.

30. "Prediction in financial markets: implications of multiscale analysis of high frequency data", Kellogg's Groups (a Wall Street company), November 10, 2006.

31. "Recurrence Time Distribution, Renyi Entropy, and Pattern Discovery", Brain Research Institute, Univ of Florida, Gainesville, March 29, 2005.

32. "Novel integrated nonlinear dynamics and random fractal theory based approaches to biomedical informatics", Harvard Medical School, Harvard Univ., Sept. 29, 2004.

33. "Recurrence time statistics and feature detection", Institute of Pure and Applied Mathematics, UCLA, May 16, 2003.

34. "Nonlinear time series analysis for quantitative neurosciences", Conference on *Quantitative Neurosciences: Models, Algorithms, Diagnostics, and Therapeutic Applications*,February 5-7, 2003. University of Florida.

35. "Recent Advances in Nonlinear Time Series Analysis with Applications to Bioengineering", The Brain Dynamics Bioengineering Research Partnership, Univ of Florida, Oct. 8, 2002.

36. "Synchronized Oscillations and Chaos in Coupled Genetic Repressilators", IPAM, UCLA, Oct. 2, 2002.

37. "Solving Massively Distributed Engineering Problems Using Nonlinear Dynamics Technique", EE, Univ of Texas, Dallas, Apr.9, 2002.

38. "Solving Massively Distributed Engineering Problems Using Nonlinear Dynamics Technique", ECE, Univ of Colorado, Boulder, March. 5, 2002.

39. "Solving Massively Distributed Engineering Problems Using Nonlinear Dynamics Technique", ECE, Univ of Florida, Feb. 6, 2002.

40. "Recent advances in the modeling of bursty traffic in computer communications networks", CISE, Univ of Missouri-Kansas city, Jan. 26, 2002.

41. "Multifractal Gene finder", CISE, Univ of Missouri-Kansas city, Jan. 26, 2002.

42. "Recent advances in the modeling of bursty traffic in computer communications networks", Computer Science and Mathematics Division, Oak Ridge National Laboratory, Oct. 30, 2001.

43. "Recent advances in the chaotic time series analysis", State Key Laboratory for Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Sept. 21, 2001.

44. "Random fractals and their applications", State Key Laboratory for Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Sept. 21, 2001.

45. "A unified classification scheme for the burstiness of network traffic". EE Dept., Iowa State Univ., March 20, 2001.

46. "A generalized multifractal model for network traffic". EE Dept., SUNY at Buffalo, Feb. 26, 2001.

47. "Multiplicative multifractal modeling of Long-Range-Dependent (LRD) traffic in computer Communications Networks". ECE Dept., University of Delaware, Jan. 19, 2001.

48. "New tools for the analysis and modeling of network traffic". National Laboratory for Applied Network Research, San Diego Super Computer Center, Jan. 17, 2001.

49. "Multifractal modeling of long-range-dependent network traffic". IMA "Hot Topics" Workshop: Scaling phenomena in communication networks. Inst. for mathematics and its applications, University of Minnesota, Oct. '99.

PROFESSIONAL SERVICE

- Associate Editor, *IEEE Trans. Biomedical Engineering*, 2006 - 2008
- Associate Editor, *Signal Processing* 2007 - 2008
- Guest Editor, Frontiers in Fractal Phisiology, special issue on methodology in Phisiology, 2012.
- Program committee member, 2nd IEEE/NIH/NSF workshop on "Life Science Systems and Applications", NLM Lister Hill Auditorium, July 2006.
- Program committee member, 10th Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD-06), Singapore, 2006.
- Program committee member, The First International Conference on Complex Sciences: Theory and Applications (COMPLEX'2009), Feb. 23-25, 2009, Shanghai, China.
- Program committee member, Spring World Congress on Engineering and Technology (SCET), May 27-30, 2012, Xi'an, China
- Program committee member, 2nd International Conference on Complex Sciences: Theory and Applications December 5-7, 2012 Santa Fe, New Mexico, United States

OTHER ACADEMIC ACTIVITIES

I have been a reviewer for various journals, publishers, conferences, and funding agencies

- *Physical Review Letters*
- *Physical Review E*
- *Physics Letters A*
- *Physica D*
- *EuroPhysics Letters*
- *PLoS ONE*
- *Scientific Reports*
- *J. Royal Society Interface*
- *Chaos*
- *Pattern Recognition Letters*
- *IEEE Tran. on Circuits and Systems*
- *IEEE Tran. on Vehicular Tech.*
- *IEEE Tran. Antennas & Propagation*
- *IEEE Tran. on Multimedia*
- *IEEE Tran. on Biomedical Eng.*
- *IEEE Tran. on Signal Processing*
- *IEEE Tran. on Audio, Speech and Language Processing*
- *IEEE Communications Letters*
- *IEEE Signal Processing Lett.*
- *Smart Structures and Systems*
- *Bulletin of Mathematical Biology*
- *Statistical Science*
- *EURASIP*
- *Journal of Sound and Vibration*
- *Wiley Interscience*, *Imperial Press*, *Prentice Hall*
- Various conferences
- proposal review for NSF, ARO, and governments of Hong Kong & Greek

RESEARCH STATEMENT

Future plan:
The amount of data in our world has been exploding. This unprecedented growth in data has offered a fascinating opportunity to extract information to aid decision making in many domains of science, engineering, healthcare, and economy. Including numerical, textual, and multimedia, these data typically are multi-modal and multiscaled, including heavy-tailed power-law behavior, and thus cannot be fully dealt with by machine learning and related approaches, especially for the purpose of finding truth in a sea of data collected in non-stationary environments with a lot of irrelevant or even false information. To maximally utilize my expertise, which is briefed below, in future, I will keep developing new multiscale analysis methods that will be broadly applicable in many areas of science and engineering, including analysis of complex signals in mechanical, electrical, biomedical, environmental engineering, and ecology.

Prior research accomplishments

(1) Multiscale signal processing and hierarchical prediction
Complex systems often generate highly nonstationary and multiscale signals because of nonlinear and stochastic interactions among their component systems and hierarchical regulations. Rapid accumulation of complex data in life sciences, systems biology, nano-sciences, information systems, and physical sciences, has made it increasingly important to develop complexity measures that incorporate the concept of scale explicitly, so that different behaviors of signals on varying scales can be simultaneously characterized by the same scale-dependent measure. Rising to this challenge, recently, I have developed a new complexity measure, the scale-dependent Lyapunov exponent (SDLE), and shown that SDLE can readily classify major types of time series models, effectively deal with nonstationarity, and simultaneously characterize the behaviors of complex signals on a wide range of scales, including complex irregular behaviors on small scales, and orderly behaviors, such as oscillatory motions, on large scales. SDLE has already found numerous applications in many areas of science and engineering, and is also the key element of the pseudo-ensemble prediction scheme we have been developing. Our book, *Multiscale Analysis of Complex Time Series*, is the first and highly regarded book on data-driven multiscale analysis of complex data.

(2) Nonlinear adaptive filtering
I have been developing a versatile adaptive filtering algorithm, to detrend/denoise complex signals. When detrending/decomposition is concerned, while the method is at least as effective as the empirical mode decomposition (EMD) based method, it is simpler and has better resolutions. When denoising is concerned, it is better than chaos and wavelet based methods, and thus is among the best and the simplest. More recently, I have also proven that the adaptive filter is a more reliable method for fractal and multifractal analysis, especially on data with significant arbitrary trends. This has opened up a new avenue for analyzing complex signals — using chaos theory to analyze the "trend" signal and multifractal theory to characterize fluctuations. This strategy is critical for studying many phenomena in geophysics, astrophysics, and especially bioengineering. Currently, the method is also being extended to image processing, including to improve bio-inspired image fusion.

(3) Nonlinear signal processing
I have very extensive research experience in the study of nonlinear dynamical systems theory. The fundamental

works that I have done include my earlier work on optimal embedding and direct dynamical test for deterministic chaos, recent works on the effects of noise on nonlinear dynamical systems, recurrence time statistics and recurrence plots, detection of nonstationarity and state transitions in signal dynamics, etc. My test for deterministic chaos is one of the more stringent and more reliable methods available in the literature that can be used to determine whether experimental data are chaotic or not. My works have been applied by researchers, world-wide, to study physical, mechanical, physiological, and financial data. My method for the study of the effects of noise on nonlinear systems is among the most powerful methods available to understand the effects of intrinsic noise on dynamical systems in general and semiconductor lasers in particular.

(4) Bioinformatics and systems biology

I have developed two unsupervised algorithms for finding genes. They both have the salient feature of being largely species-independent and working very well on short DNA sequences, and therefore, may be especially effective in finding genes that are not in the known databases. For example, using BLAST (Basic Local Alignment and Search Tool), the most popular method for comparative genomic search, researchers found that only less than 10% of the short DNA sequences of the marine viromes of four oceanic regions are similar to those in the known databases. Our approaches, not requiring any prior knowledge, will be excellent means of identifying new genes from these virome genomes.

Recently, I and my collaborators at Mount Sinai Medical School have also developed a novel method of detecting chromosomal aberrations from Microarray-based Comparative Genomic Hybridization (array CGH) data. Our method is the first to fully take into account non-Gaussian and long-range spatial correlations of the array CGH data, and is much more accurate and faster than existing methods. Both features are extremely important for analyzing whole genome scale arrays with increasing resolutions.

Motivated by shedding light on how collective dynamical behaviors, such as genome-wide oscillations, period doubling and possibly strange attractors associated with cell division cycle may occur, we have developed an interesting coupled genetic oscillator model. We find that synchronized oscillations may occur between nearly matched oscillators, and that chaos can occur via a period doubling route. Our work offers an interesting framework to model laboratory biochemical experiments, which take place in space in a distributed way, and naturally explains why the periods of the genetic oscillators observed in experiments vary so considerably.

(5) Biomedical engineering

I have developed many novel methods to analyze various types of biomedical signals, including EEG (brain waves), heart rate variability (HRV) data, pathologic tremors, switching times in ambiguous visual perception, neuronal firing data, and functional magnetic resonance imaging (fMRI) data. While some of my methods may become part of the standard toolbox for biomedical signal/image processing in future, it is worthing emphasizing that for distinguishing healthy subjects from patients with congestive heart failure, my new multiscale complexity measure, the scale-dependent Lyapunov exponent, is more effective than major complexity measures from information theory, chaos theory, and random fractal theory. It is also worthing emphasizing that my recurrence-time based method for detecting/predicting epileptic seizures from EEG holds the promise of being deployed clinically, being fast enough to be used in real-time and more accurate than existing methods.

(6) Nano- and fault-tolerant computations

In emerging nanotechnologies, reliable computation will have to be carried out with unreliable components

being integral parts of computing systems. By now, the only theoretical framework available to build reliable systems using faulty components is von Neumann's M-modular multiplexing technique, realized by using either noisy NAND gates or majority gates. I have developed a bifurcation theory based new language to find the exact error threshold values for noisy NAND and majority gates with an arbitrary number of inputs. I have also developed an effective framework for characterizing system reliability.

(7) Sea clutter modeling and target detection within sea clutter

Sea clutter is the radar backscatter from a patch of ocean surface. The complexity of the signals comes from two sources: the rough sea surface, sometimes oscillatory, sometimes turbulent, and the multipath propagation of the radar backscatter. Robust detection of targets from sea clutter radar returns is an important problem in remote sensing and radar signal processing applications. By using random fractal theory and my newly developed multiscale analysis approaches, I have finally been able to elucidate the complicated correlation structure of sea clutter data. Using about 400 datasets made available publicly by Professor Simon Haykin at McMaster University, I have developed a number of methods, with an accuracy very close to 100%, to detect low observable targets within sea clutter. In contrast, most works published in the literature have only used a few datasets of Professor Simon Haykin's.

(8) Network traffic modeling and Internet dynamics

Three of the most important network performance measures are buffer size, packet delay time, and packet loss probability. I am the first to quantitatively show how the most popular teletraffic model, the Poisson model, underestimates buffer size, packet delay time, and packet loss probability by several orders of magnitude compared to a queueing system driven by actual traffic trace data. The failure of the Poisson model has motivated me to carefully study the pros and cons of many long-range-dependent (LRD) traffic models, and found that real-time Hurst parameter estimation as an on-line prediction and control tool has its serious limitations. These works have motivated me to develop multifractal based traffic models, whose performance is much better than other models.

Recently, I have found that the traffic measured at the core of the Internet is typically a mixture of Poisson, LRD, and deterministic traffic components, and hence, is very heterogeneous. To effectively model such traffic, I have developed a stage-dependent multiplicative process model. The model wonderfully generates process model. The model wonderfully generates traditional short-range-dependent models such as Poisson model, conventional LRD traffic models, and pure multiplicative multifractal models as special cases. I have also developed a new and universal mechanism for the origin of LRD traffic. The mechanism is strictly network-based and protocol-independent, and naturally explains why Internet core traffic is a mixture of Poisson, LRD, and deterministic traffic components. This work paves the way for me and my collaborator, Dr. Nagi Rao at ORNL, to develop an effective theoretical framework to simultaneously characterize the interaction between the deterministic and stochastic behaviors in the Internet. This is important in emerging applications such as computational steering and instrument control, which require stable control channels be supported over wide-area connections.