

# Curriculum Vitae: Michael Kirby (Professor) Co-Director Pattern Analysis Laboratory (PAL)

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## Personal Data

Born Boulder, Colorado  
United States Citizen

## Education

1988 Ph.D. Applied Mathematics, Brown University, Providence, RI  
1986 Sc.M. Applied Mathematics, Brown University, Providence, RI  
1984 S.B. Mathematics, MIT, Cambridge, MA

## Academic Appointments

1999– Professor, Department of Mathematics, Colorado State University  
2004– Professor, Department of Computer Science, Colorado State University  
1995–99 Associate Professor, Department of Mathematics, Colorado State University  
1991–95 Assistant Professor, Department of Mathematics, Colorado State University

## Research Interests

- **Theory and Algorithm Development:** Geometric methods and pattern analysis, optimization on manifolds, nonlinear data reduction, time-series analysis, function approximation over high dimensional domains, signal and image processing. Spatio-temporal multi-scale analysis.
- **Applications:** Low-dimensional representation of data. Modeling of dynamical systems. Pattern recognition. Analysis of video sequences, face recognition and machine lip reading. Fault detection and failure prediction. The human computer interface problem. The characterization of landscape and forest images.

## Fellowships, Honors, Awards

- Alexander von Humboldt Fellowship, Institute for Information Sciences University of Tuebingen, Federal Republic of Germany. (1989-1991)
- IBM Faculty Award (2002)
- College of Natural Sciences Award for Graduate Student Education (2002)
- Visiting Research Fellowship, Engineering and Physical Sciences Research Council, United Kingdom (1996-1997)
- DARPA Fellowship, Center for Fluid Dynamics, Turbulence and Computation, Brown University. (1988-1989)
- Elected full member, Sigma Xi, Brown University Chapter. (1988)

## Contracts and Grants

1. Principal Investigator, *Synergistic Mathematics: Colorado State University-Poudre School District*, the Bohemian Foundation, 2007-2008.
2. CO-Principal Investigator, *CMG: Analysis of Transport, Mixing, and Coherent Structures in Hurricane Intensity*, NSF ATM-530884, 2006-2009.
3. Principal Investigator, National Science Foundation *MSPA-MCS: New Tools for Algebro-Geometric Data Analysis*, 2004-2007.
4. CO-Principal Investigator, *Geometric Pattern Analysis and Mental Task Design for a Brain-Computer Interface*, NSF IIS-0208958, Funding 9/15/02–8/15/06.
5. Principal Investigator, *Multiscale Analysis of Vegetation Disease*, United States Forest Service, 8/16/04-7/31/06.
6. Principal Investigator, DOD USAF Office of Scientific Research, Contract # FA9550-04-1-0094, *Geometric, Algebraic and Topological Invariants for Signal and Image Processing*, 2/15/04–2/14/07
7. Principal Investigator, *Face Manifolds for Recognition*, Directorate of Central Intelligence, NMA501-03-BAA-0001, 2003-2005
8. Principal Investigator, *A Mathematical Modeling Program for Undergraduates in Science, Mathematics, Engineering & Technology*, NSF DUE-0126650, 2002-2005.
9. Siemens Corporate Research, Princeton N.J., Fault detection and failure prediction in signal processing, 2003.
10. Principal Investigator, *The Whitney Reduction Network*, National Science Foundation DMS 997330, 2000-2003.
11. Principal Investigator, *Wavelet Analysis for Detecting and Characterizing Landscape-Scale Patterns of Forest Disturbance*, United States Forest Service, 2001-2002 .

12. IBM Faculty Award: *A Radial Basis Function Approach for Nonlinear Gamut Mapping*, 2002.
13. Principal Investigator, *Image Mining of Sensed Data*, Technical Management Concepts, Inc., 2000-2001.
14. Principal Investigator, DOD USAF Office of Scientific Research, Contract # F49620-99-1-0034, *A Reductionist Approach to Process Discovery*, 1999-2001
15. Principal Investigator, *Development of a MATLAB Novelty Detection Algorithm*, Honeywell Corporation, 5/15/00–8/15/00.
16. Honeywell, INC: Asset Analysis II, 1999-2000.
17. Honeywell Inc, Principal Investigator, *Asset Analysis*, 1998-1999.
18. CO-Principal Investigator National Science Foundation Award DMS-9406144, *A Taylor-Couette Simulator*, 1996-1999.
19. Principal Investigator National Science Foundation Award INT-9513880, *U.S.-Germany Cooperative Research on Attractive Invariant Manifolds in High-Dimensional Symmetric Systems*, 1996-1998.
20. Principal Investigator National Science Foundation Award ECS-9312092, *Low-Dimensional Invariant Coordinate Systems for Dynamic Modeling*, 1993-1996

## Publications

1. Jen-Mei Chang, M. Kirby, H. Kley and C. Peterson, R. Beveridge, B. Draper, *Recognition of Digital Images of the Human Face at Ultra Low Resolution via Illumination Spaces*, Springer Lecture Notes in Computer Science, Vol. 4844, pg 733-743, (2007).
2. Jen-Mei Chang, Michael Kirby and Chris Peterson, *Set-to-Set Face Recognition Under Variations in Pose and Illumination*, 2007 Biometrics Symposium, Baltimore, MD, September, 2007.
3. A. Jamshidi and M. Kirby, *A spatio-temporal criterion for automatic model order determination*, SIAM Journal of Scientific Computing, Vol. 29, 941, May, 2007.
4. Jen-Mei Chang, Michael Kirby, Holger Kley, Chris Peterson, J.R. Beveridge and Bruce Draper, *Examples of Set-to-Set Image Classification*, In: Seventh International Conference on Mathematics in Signal Processing Conference Digest, The Royal Agricultural College, Cirencester, Institute for Mathematics and its Applications, December, 2006, pp. 102–105.
5. Yue Qiao, Larry Ernst and M. Kirby, *Developing a Computational Radial Basis Function (RBF) Architecture for Nonlinear Scattered Color Data*, Proceedings NIP22 International Conference on Digital Printing Technologies, Sept. 2006.
6. C. Anderson, M. Kirby, J.N. Knight, Classification of Time Embedded EEG Using Short Time Principal Component Analysis, (Book Chapter to appear) In *Towards Brain Computer Interfacing*, edited by G. Dornhege, J. del R. Millan, T. Hinterberger, D.J. McFarland, and K.R. Müller, The MIT Press, 2006.
7. J.M. Chang, R. Beveridge, B. Draper, M. Kirby, H. Kley and C. Peterson, *Illumination Face Spaces are Idiosyncratic*, IPCV'06, Vol 2., 390-396, 2006, CSREA Press.

8. Anderson, C.W., Knight, J.N., O'Connor, T., Kirby, M.J., and Sokolov, A. (2006) Geometric Subspace Methods and Time-Delay Embedding for EEG Artifact Removal and Classification, *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 14, no. 2, pp. 142–146, June 2006.
9. A. A. Jamshidi and M. J. Kirby, *Examples of Compactly Supported Functions for Radial Basis Approximations*, Proceedings of The 2006 International Conference on Machine learning; Models, Technologies and Applications, Editors H. R. Arabnia, E. Kozerenko and S. Shaumy, 155-160, 2006.
10. Anderson, C.W., Knight, J.N., Kirby, M.J. (2005) An Inexpensive Brain-Computer Interface Based on Spatial and Temporal Analysis of EEG. Proceedings of HCI International, (HCI-I) 2005, Las Vegas, NV, (CD-ROM).
11. David A. Peterson, James N. Knight, Michael J. Kirby, Charles W. Anderson and Michael H. Thaut, Feature selection and blind source separation in an EEG-based brain-computer interface, *EURASIP Journal on Applied Signal Processing*, vol. 2005, issue 19, pp. 3128-3140.
12. D. Broomhead and M. Kirby, *Large Dimensionality Reduction using Secant-based Projection Methods: The Induced Dynamics in Projected Systems*, *Nonlinear Dynamics* 41(1-3) (August 2005), pp. 47-67.
13. M. Kirby, *Nonlinear Signal Processing*, *Encyclopedia of Nonlinear Science*, ed. Alwyn Scott. New York and London: Routledge, 2004.
14. A. Fox, M. Kirby, M. Montgomery, J. Persing, A Comparison of Optimal Low Dimensional Projections of a Hurricane Simulation. In: *Dynamics and Bifurcation of Patterns in Dissipative Systems*, G. Dangelmayr and I. Oprea (eds.), *World Scientific Series on Nonlinear Science*, Vol. 12, pages 292-308, World Scientific, Singapore, 2004
15. Fatemeh Emdad, Seyed A. Zekavat, Michael Kirby: Adaptive Antenna Beam Forming Via Maximum Noise Fraction for Multi Carrier CDMA Systems. *International Conference on Wireless Networks 2003*: 431-437
16. Seyed A Zekavat, Fatemeh Emdad and Michael Kirby, A Merger of Maximum Noise Fraction Beam Forming and MC-CDMA Systems: Perturbation Analysis in Dispersive Channels, *Proceedings IEEE 37th Asilomar conference on Signals, Systems and Computers*, Nov. 9-12, 2003.
17. Charles Anderson and Michael Kirby, EEG Subspace Representation and Feature Selection for Brain Computer Interface, *1st IEEE Workshop on Computer Vision and Pattern Recognition for Human Computer Interaction (CVPRHCI)*, Madison, WI, June 17, 2003.
18. D. Hundley and M. Kirby, Estimation of Topological Dimension, *Proceedings of the Third SIAM International Conference on Data Mining*, D. Barbara and C. Kamath (editors), SIAM 2003, pgs. 194-202
19. Michael Kirby and Charles Anderson, Geometric Analysis for the Characterization of Nonstationary Time Series, in *Perspectives and Problems in Nonlinear Science: A Celebratory Volume in Honor of Larry Sirovich*, Editors: Ehud Kaplan, Jerrold E. Marsden, Katepalli R. Sreenivasan, March 2003.

20. Douglas R. Hundley, Michael J. Kirby, and Markus Anderle, Blind source separation using the maximum signal fraction approach, Douglas R. Hundley, Michael J. Kirby, and Markus Anderle, *Signal Processing* Volume 82, Issue 10, October 2002, Pages 1505-1508
21. M. Anderle, D. Hundley and M. Kirby, The Bilipschitz criterion for mapping design in data analysis, *Intelligent Data Analysis*, Volume 6, Number 1, 2002, pages 85–104.
22. M. Anderle and M. Kirby, An Application of the Maximum Noise Fraction Method to Filtering Noisy Time-Series, in *Mathematics in Signal Processing V*, Editors: J. G. McWhirter and I. K. Proudler, Oxford University Press, June 2002.
23. D. Hundley, M. Kirby and Markus Anderle, *A Solution Procedure for Blind Signal Separation using the Maximum Noise Fraction Approach: Algorithms and Examples*, *Proceedings of the Conference on Independent Component Analysis*, San Diego, CA, pages 337–342., December, 2001
24. M. Anderle and M. Kirby, *Correlation Feedback Resource Allocation RBF*, *Proceedings of the International Joint conference on neural Networks*, vol 3., pages 1949-1953, 2001.
25. D.S. Broomhead and M. Kirby, *The Whitney Reduction Network: a method for computing autoassociative graphs*, *Neural Computation* 13:2595-2616, 2001.
26. M. Anderle, M. Kirby, and A. Todd. *Identifying Structure in High-Dimensional Data Sets using Connectivity Matrices*. *SIAM Workshop on Mining Scientific Datasets*. Chicago, pages 29-36. April 7, 2001.
27. A. Todd and M. Kirby. *Data Visualization via Structured Voronoi Cell Refinement*. *SIAM Workshop on Mining Scientific Datasets*. Chicago, pages 45-52. April 7, 2001.
28. D.S. Broomhead and M. Kirby, *A New Approach for Dimensionality Reduction: Theory and Algorithms*, *SIAM J. of Applied Mathematics*, vol. 60, no. 6, pp. 2114–2142, 2000.
29. M. Anderle and M. Kirby, *Filtering Noisy Time Series: Keeping the Baby and Most of the Bathwater*, *Conference Digest, Fifth IMA International Conference on Mathematics in Signal Processing*, Univeristy of Warwick, 2000
30. Shawn Martin, Michael Kirby and Rick Miranda, *Symmetric Veronese Classifiers with Application to Materials Design*, *Engineering Applications of Artificial Intelligence*, 13:513-520, 2000.
31. Shawn Martin, Michael Kirby and Rick Miranda, *Kernel/Feature selection for support vector machines applied to materials design*, In *IFAC Symposium on Artificial Intelligence in Real Time Control AIRTC-2000*, Budapest, Hungary, pp 29-34, Elsevier Science, 2000.
32. Empirical Dynamical System Reduction I: Global Nonlinear Transformations, (with R. Miranda), Editor K. Coughlin, In *Semi-Analytic Methods for the Navier-Stokes Equations (Montreal, 1995)*, Vol.20, 41-64, CRM Proc. Lecture Notes, Amer. Math. Soc., Providence, RI. 1999
33. Empirical Dynamical System Reduction II: Neural Charts, (with D.Hundley and R.Miranda) Editor K. Coughlin, In *Semi-Analytic Methods for the Navier-Stokes Equations (Montreal, 1995)*, Vol.20, 65-83, CRM Proc. Lecture Notes, Amer. Math. Soc., Providence, RI. 1999
34. Adaptive Clustering Based on Local Neighborhood Interactions, (with Markus Anderle), *Proc. SPIE Vol. 3807, Advanced Signal Processing Algorithms, Architectures, and Implementations IX*, Editor Franklin T. Luk, 1999

35. A New Optimal Basis for Image Representation, (with D. Dreisigmeyer), Proc. SPIE Vol. 3814, Mathematics of Data/Image Coding, Compression and Encryption II, Editor M. Schmalz, 1999
36. Time series prediction by estimating Markov probabilities through topology preserving maps, (with G. Dangelmayr and S. Gadaleta and D. Hundley), Proc. SPIE Vol. 3812, In: Applications and Science of Neural Networks, Fuzzy Systems, and Evolutionary Computation II, 86–93, Editors B. Bosacchi and D. B. Fogel and J.C. Bezdek, 1999
37. M. Kirby 1998, *Ill-Conditioning and Gradient Based Optimization of Multi-Layer Perceptrons*, Eds. J.G. McWhirter and I.K. Proudler, Mathematics in Signal Processing IV, pp223-237, Oxford University Press, The Institute of Mathematics and Its Applications Conference Series: No. 67”,
38. M. Kirby and R. Miranda (1996), *Circular Nodes in Neural Networks*, Neural Computation, Vol. 8, No. 2, p. 390-402.
39. M. Kirby 1996, *Optimal Empirical Transformations with Applications: A Summary*, Conference Digest, Fourth International Conference on Mathematics in Signal Processing, 1996.
40. D. Hundley M. Kirby and R. Miranda (1995), *Spherical Nodes in Neural Networks*, Intelligent Engineering Through Artificial Neural Networks, Vol. 5, Eds. S.H. Dagli, B.R. Fernandez, J. Ghosh and R.T. Soundar Kumara.
41. M. Kirby and R. Miranda (1994), *Nonlinear reduction of high-dimensional dynamical systems via neural networks*, Phys. Rev. Letters, Vol. 72, No. 12, p. 1822.
42. M. Kirby and R. Miranda (1994), *The Remodeling of Chaotic Dynamical Systems*, Intelligent Engineering Through Artificial Neural Networks, Vol. 4, Eds. S.H. Dagli, B.R. Fernandez, J. Ghosh and R.T. Soundar Kumara.
43. E. Stone and M. Kirby (1993), *Dependence of bifurcation structures on the approximation of  $O(2)$  symmetry in minimal ODEs*, in Exploiting Symmetry in Applied and Numerical Analysis, Lectures in Applied Mathematics, Eds. E.L. Allgower, K. Georg and R. Miranda, Vol. 29, p. 389-404.
44. M. Kirby, F. Weisser and G. Dangelmayr (1993), *Speaking with images: a model problem in the representation of digital image sequences*, Pattern Recognition, 26 No. 1, 63.
45. M. Kirby and D. Armbruster (1992), *Reconstructing phase-space from PDE simulations*, Z. angew. Math. Phys., 43, 999.
46. G. Dangelmayr and M. Kirby (1992), *On Diffusively Coupled Oscillators*, Intl. Ser. of Num. Math., Vol. 104 p. 85-97.
47. M. Kirby (1992), *Minimal dynamical systems from partial differential equations using Sobolev eigenfunctions*, Physica D 57 p. 466-475
48. M. Kirby (1992), *Low-Dimensional Techniques for Processing Still and Moving Images*, IEEE proceedings on Signal Processing, Asilomar 1026.
49. M. Kirby, F. Weisser and G. Dangelmayr (1991), *A problem in facial animation: analysis and synthesis of lip motion*, Proc. of the 7th Scandinavian Conf. on Image Analysis, Aalborg, Denmark, ed: P. Johansen and S. Olsen p. 529.

50. M. Kirby, D. Armbruster and W. Güttinger (1991), *An approach for the analysis of spatially localized oscillations*, Bifurcations and Chaos: Analysis, Algorithms and Applications, Intl. Ser. of Num. Math., Vol. 97, ed: R. Seydel, F.W. Schneider, T. Küpper, H. Troger, Birkhäuser Verlag Basel p. 183.
51. M. Kirby, J.P. Boris and L. Sirovich (1990), *An eigenfunction analysis of axisymmetric jet flow*, J. of Computational Physics Vol. 90, No. 1 p. 98.
52. M. Kirby, J.P. Boris and L. Sirovich (1990), *A proper orthogonal decomposition of a simulated supersonic shear layer*, Intl. J. for Numerical Methods in Fluids Vol. 10, p. 411-428.
53. L. Sirovich, M. Kirby and M. Winter (1990), *An eigenfunction approach to large-scale structures in transitional jet flow*, Phys. Fluids A **2(2)** p.127.
54. M. Kirby and L. Sirovich (1990), *Application of the Karhunen-Loève procedure for the characterization of human faces*, IEEE trans. PAMI Vol. 12, No. 1 p. 103.
55. L. Sirovich and M. Kirby (1987), *A low dimensional procedure for the characterization of human faces*, J. of the Optical Society of America **A**, Vol. 4., p. 519.