# Anthony Brockwell

(CV last updated Nov. 24th, 2009.)

abrock@stat.cmu.edu
www.stat.cmu.edu/~abrock
Citizenship: U.S., Australia (dual)


---

## Education

1994-1998 : Ph.D., Department of Statistics and Department of Electrical Engineering at Melbourne University, Advisors: K. Borovkov, R. Evans

1993 : Honours Science Degree (in the Department of Statistics) completed at Melbourne University (H1)

1988-92 : Bachelor of Science and Bachelor of Engineering with Honours completed at Melbourne University

## Employment

2007+ : Adjunct Associate Professor, Department of Statistics, Carnegie Mellon University

2007-2009 : Senior Analyst/Trader, Horton Point LLC (Hedge Fund Management Company)

2006-2007 : Associate Professor, Department of Statistics, Carnegie Mellon Uniuversity

2005-2007 : Affiliated faculty member, Machine Learning Department (formerly known as the Center for Automated Learning and Discovery), Carnegie Mellon University

2003-2007 : Faculty member, Parallel Data Lab (PDL), Carnegie Mellon University

2002-2005 : Assistant Professor, Department of Statistics, Carnegie Mellon University

1999-2002 : Visiting Assistant Professor, Department of Statistics, Carnegie Mellon University

1998-1999 : Research Fellow, Department of Electrical and Electronic Engineering, The University of Melbourne

1993-1995 : Sessional Tutor, Department of Statistics, The University of Melbourne

## Recent Professional Activities

Horton Point:

**Strategy Development**
Experience includes extensive analysis of futures price data at different frequencies, development of automated trading strategies based on the results, development of (high-frequency) execution algorithms to support these strategies.

**Trading and Production**
Implementation of trading strategies and associated execution algorithms, analysis of performance and reconciliation with back-testing results, manual trading when necessary to correct positions, capital allocation between strategies, interaction with IT department in development of supporting tools.

Carnegie Mellon:

**Teaching**
One half-semester course: Financial Time Series Analysis (46-929) taught once a year (March to May) to Tepper Business School students in the Masters in Computational Finance program. (See `www.tepper.cmu.edu/master-in-computational-finance/index.aspx`) The course covers concepts of stationarity, ARMA, ARIMA, and ARCH/GARCH models, and provides a basic introduction to quantitative trading algorithms. (Faculty-course evaluations available on request.)

**Research**
Primary emphasis is on development of new time series models relevant to financial modeling, as well as completing publication of papers with former students.

Extra-Curricular:

**Software Development**
Sole developer of "Cronos" (`www.codeplex.com/cronos`), an open-source time series analysis package with GUI included. It provides tools for data manipulation, supports fitting of different models, including ARMA and GARCH as well as multivariate models, and provides a graphical framework for representation of the analysis process. A plugin framework allows developers to create their own custom models and transforms.

## Refereed Journal/Book Publications

Anthony Brockwell, Pierre Del Moral, Arnaud Doucet, *Sequentially Interacting Markov Chain Monte Carlo Methods*, To appear, 2010, Annals of Statistics

B.R. Rambarhat and A.E. Brockwell, *Sequential Monte Carlo Pricing of American-Style Options with Stochastic Volatility Models*, To appear, 2010, Annals of Applied Statistics

K. L. Myers, A.E. Brockwell and W. F. Eddy, *State-space models for optical imaging*, Statistics in Medicine, Vol. 26(21), 2007, pp. 3862–3874

A.E. Brockwell, R.E. Kass and A.B. Schwartz, *Statistical Signal Processing and the Motor Cortex*, Proc. IEEE, Vol. 95(5), 2007, pp. 881–898

M. Serban, J. Lehoczky, A. Brockwell and S. Srivastava, *Modeling the Dynamic Dependence Structure in Multivariate Financial Time Series* Vol. 28(5), 2007, Journal of Time Series Analysis

A.E. Brockwell, *Universal Residuals: A Multivariate Transformation*, Statistics and Probability Letters, Vol. 77, 2007, pp. 1473–1478

S. Mitra, M. Savvides, and A. Brockwell, *Statistical Performance Evaluation of Biometric Authentication Systems using Random Effects Models*, IEEE Transactions on Pattern Analysis and Machine Intelligence, Vol. 29(4), 2007, pp. 517–530

A.E. Brockwell, *Likelihood Based Analysis of A Class of Generalized Long Memory Models*, Journal of Time Series Analysis, Vol. 28(3), 2007, pp. 386–407

A. Brockwell and M. Velliste, *Brain-Machine Interfacing and Motor Prosthetics*, Chapter 10, Mechatronic Systems - Devices, Design, Control, Operations and Monitoring, CRC Press, Taylor & Francis, Boca Raton, FL

A.E. Brockwell, *Parallel Processing in Markov chain Monte Carlo Simulation by Pre-Fetching*, Journal of Computational and Graphical Statistics, Vol. 15(1), 2006, pp. 246–261

A.E. Brockwell and N.H. Chan, *Long Memory Dynamic Tobit Models*, Journal of Forecasting, Vol. 25(5), 2006, pp. 351–267

A.E. Brockwell and J.B. Kadane, *Identification of Regeneration Times in MCMC Simulation, with Application to Adaptive Schemes*, Journal of Computational and Graphical Statistics, Vol. 14(2), 2005, pp. 436–458

B. Ricky Rambarhat, Anthony Brockwell and Duane Seppi, *A Threshold Autoregressive Model for Wholesale Electricity Prices*, Journal of the Royal Statistical Society Series C, Vol. 54(2), 2005, pp. 287–299

S. Papadimitriou, A. Brockwell, and C. Faloutsos, *Adaptive, Unsupervised Stream Mining*, the International Journal on Very Large Databases, Vol. 13(3), 2004, pp. 222–239

A. Brockwell, A. Rojas and R. Kass, *Recursive Bayesian Decoding of Motor Cortical Signals by Particle Filtering*, Journal of Neurophysiology, Vol. 91, 2004, pp. 1899–1907

A.E. Brockwell, N.H. Chan, and P.K. Lee, *A Class of Models for Aggregated Traffic Volume Time Series*, Journal of the Royal Statistical Society Series C, Vol. 52(4), 2003, pp. 417–430

A.E. Brockwell and J.B. Kadane, *A Gridding Method for Bayesian Sequential Decision Problems.* Journal of Computational and Graphical Statistics, Vol. 12(3), 2003, pp. 566–584

A. Brockwell, E. Polak, R. Evans, and D. Ralph. *Dual-Sampling-Rate Moving Horizon Control of a Class of Linear Systems with Input Saturation and Plant Uncertainty.* Journal of Optimization Theory and Applications. Vol. 116(3), 2003, pp. 485–516

A. Brockwell. *A Regulator for a Class of Unknown Continuous-Time Nonlinear Systems.* Systems and Control Letters. Vol. 44, 2001, pp. 405–412

A. Brockwell, R. Evans and I. Mareels. *Stability of a Trajectory-Based Control Law for an Unknown Nonlinear Non-Minimum Phase System* . The Asian Journal of Control. Vol. 3(1), 2001

A. E. Brockwell and P. J. Brockwell. *A Class of Non-Embeddable ARMA Processes.* Journal of Time-Series Analysis, Vol. 20, Number 5, September 1999, pp. 483-486

A. Brockwell, K. Borovkov and R. Evans. *Stability of an Adaptive Regulator for Partially Known Nonlinear Stochastic Systems.* SIAM J. on Control and Opt., Vol. 37(5), 1999, pp. 1553-1567

**Refereed Conference Papers**

A.E. Brockwell, *Filtering of Neural Signals for Mental Control of Robotic Prosthetic Devices*, Nonlinear Statistical Signal Processing Workshop (NSSPW), Cambridge, U.K., Sept. 2006

S. Mitra, M. Savvides and A. Brockwell, *Modeling Phase Spectra using Gaussian Mixture Models for Human Face Identification*, International Workshop on Information Fusion for Biometric Processing (ICAPR), Aug. 2005

M. Wang, K. Au, N. Ailamaki, A. Brockwell and C. Faloutsos, *Storage Device Performance Prediction with CART Models*, MASCOTS Conference, Volendam, The Netherlands, 2004

A. Greenfield and A. Brockwell, *Adaptive Control of Nonlinear Stochastic Systems by Particle Filtering*, Proceedings of the 4th International Conference on Control and Automation, Montreal, Canada, 2003, pp. ThA01-6

A. Brockwell, R. Evans and K. Borovkov, *Adaptive Control of a Class of Nonlinear Stochastic Systems with Input Constraints.* IFAC Workshop on Adaptive Control and Signal Processing, Glasgow, 1998

A. Brockwell, K. Borovkov and R. Evans. *Regulation of Partially Known Nonlinear Stochastic Systems Using Fast Identification.* Proceedings of the 36th IEEE CDC, San Diego, 1997, Vol. 4, pp. 3964-3969

**Some Non-refereed Publications/Technical Reports**

A. Brockwell, C. Kaufman, A. Rojas, V. Ventura, R. Kass, *Particle Filtering for Mind-Reading*, Poster, First Cape Cod Workshop on Monte Carlo Methods, Cape Cod, 2002

A.E. Brockwell, *Software Review: A Library for Regenerative MCMC Simulation.* The ISBA Bulletin. Vol 9(1), 2002, p. 9

M.W. Grigg, A. Keating, A. Brockwell and Z. Barnea *Microcomputer-based acquisition system for the Philips PW1050 powder diffractometer* . Journal of Applied Crystallography, Vol. 25, Part 5, 1992, pp. 652-653

Appendix A, P. J. Brockwell and R. A. Davis, *ITSM: An Interactive Time-Series Modelling Package for the PC*, Springer-Verlag, 1991

Manuela Buzoianu, Anthony E. Brockwell and Duane J. Seppi, *A Dynamic Supply-Demand Model for Electricity Prices*, CMU Stats. Tech. Report #817, 2005

Alex L. Rojas, Anthony E. Brockwell and Andrew B. Schwartz, *Improved Models for Analysis of*

*Motor-Cortical Signals*, CMU Stats Tech. Report #815, 2005

A. Brockwell, *A Compensator for Unknown Slowly Time-Varying Input Offsets in Continuous-Time State-Feedback Systems*, CMU Stats Tech. Report #724, 2000

## Funded Research Proposals

* MDA (Missile Defence Agency) STTR Phase I proposal, B033-0015, *Data Driven Prognostics*, 7/15/03-1/31/04 (PI)

NSF Grant IIS-083148, *Data Mining Meets I/O Performance Evaluation: Advanced Statistical Tools for Analyzing Bursty Traffic*, 9/1/01-8/31/04 (Co-PI)

NSF Grant CCR-0326453, *Self Storage Systems*, 10/15/03-9/30/07 (Co-PI)

* NSF Grant DMS-053208, *SCREMS (Scientific Computing Research Environments for the Mathematical Sciences)*, 9/15/05-10/15/05 (Co-Pi)

NIH Grant R21 EB005967-01A1, *Development of a Prosthetic Finger for Muscle Control Investigation*, 9/26/05-8/31/07 (Co-Pi)

NIH Grant R01 EB005847-01 (CRCNS), *Analysis of Multi-Neuronal Data: Cortical Plasticity During Learning*, 9/1/05-9/30/09 (Co-Pi)

NIH Grant R01 MH064537-04AZ (NIMH), *Analysis of Nonstationary Point Process Data*, 4/1/2006-3/31/2010 (Co-PI)

(* indicates Brockwell was primary author of proposal)

## Invited Seminars/Courses

*Quantitative Trading in Practice* Symposium on Computational Finance with R, Columbia University, November 2008.

*So What is a Hedge Fund Anyway?* Machine Learning Dept., Carnegie Mellon University, March 2008.

*Universal Residuals*, Graybill Conference VI: Applied Probability Symposium in honor of Peter Brockwell, Ft. Collins, Colorado, June 2007.

*Brain-Machine Interfacing: Direct Mental Control of a Robotic Arm*, CRM-ISM-GERAD Colloque, Montreal, Quebec, Canada, 2007.

*A Brief Introduction to Adaptive MCMC and Sequential Monte Carlo*, JSM, 2006, Seattle.

*Sequentially Interacting Markov Chain Monte Carlo Simulation* IMS workshop on Bioinformatics, 2006, Vancouver.

*Filtering of Neuronal Signals in the Motor Cortex* Workshop for IEEE Proc. special issue on large scale dynamical systems, Niagara-on-the-Lake, Canada, June 2006.

*Statistical Analysis of Neural Responses for Communication Technologies*, NIDCD/ORD Workshop on Brain Computer Interfaces for Speech Synthesis, Bethesda, Maryland, May 2006

One lecture of *Bayesian Networks and Graphical Models*, Center for Automated Learning and Discovery Summer School course, Carnegie Mellon University, June 2005

*Generalizing the Hidden Markov Model*, Center for Automated Learning and Discovery, Carnegie Mellon University, 2004

*Monte Carlo Methods for Option Pricing*, Short course (12 hours), The University of Melbourne, August, 2004

*Granger Causality and Time Series Analysis of Neuronal Data*, Kavli Institute for Theoretical Physics, "Understanding the Brain Program", Santa Barbara, 2004

*Parallelization of MCMC*, SGI and Duquesne University Discovery Summit on High Performance Computing, Pittsburgh, 2004

*Useful Signals from Motor Cortex* (with Andy Schwartz and Valerie Ventura), Statistical Analysis of Neuronal Data Workshop, Pittsburgh, 2004

*Generalized Long-Memory Time Series Models and Stochastic Volatility*, University of Chicago, Graduate School of Business Statistics and Economics Colloqium, 2004

*Mind-Machine Interfacing: Neural Decoding by Particle Filtering*, Carnegie Mellon University Machine Learning Lunch Seminar, 2004

*Particle Filtering for Neural Decoding*, Case Studies in Bayesian Statistics, Workshop #7, Carnegie Mellon University, 2003

*A Gridding Method for Bayesian Sequential Decision Problems*, Joint Statistical Meetings, San Francisco, 2003

*Practical Regeneration for MCMC Simulation*, Joint Statistical Meetings, New York, 2002

*Controlled Nonlinear Time Series and Autoregressive Processes in Continuous Time*, Joint Statistical Meetings, Atlanta, 2001

*A Computational Method for Finding Solutions to Sequential Decision Problems*, Department of Statistics, Colorado State University, 2001

*Regulation of Partially Known Nonlinear Systems Using Fast Identification*, Department of Electronic Engineering, Colorado University, 1997

*Control of Partially Known Nonlinear Systems Using Fast Identification*, Department of Statistics, Colorado State University, 1996 and Systems Research Lab, University of Illinois at Champagne-Urbana, 1996

**Other Conference Presentations**

*Filtering of Neural Signals for Mental Control of Robotic Prosthetic Devices*, Nonlinear Statistical Signal Processing Workshop, Cambridge (UK), 13-15 Sep. 2006

*A Class of Models for Aggregated Network Traffic Volume*, NBER/NSF Time Series Conference (in Honor of George Tiao's Retirement), Chicago, 2003

## Selected Teaching Experience

46-929 : **Financial Time Series Analysis, Tepper School of Business, 2001-2009.** This masters-level course is part of the Masters of Science in Computational Finance program at Carnegie Mellon University. covers classical time series models as well as nonlinear and non-Gaussian models, particularly GARCH and stochastic volatility models. It includes an introduction to algorithmic trading based on these models.

36-728,730 : **Time Series Analysis I/II, Statistics Dept., 2000-2004, 2006.** This is a Ph.D.-level course on time series analysis.

36-752 : **Advanced Probability Overview, Statistics Dept., 2005.** This Ph.D.-level course covers probability theory. Topics include measurability, integration, modes of convergence, conditional distributions, among others.

36-703 : **Intermediate Probability, Statistics Dept., 2000.** This masters-level course covers some basics of probability theory, and concentrates more specifically on stochastic processes, particular Markov processes.

36-217 : **Probability Theory and Random Processes, Statistics Dept., 1999-2000, 2003.** This is an introductory undergraduate course on probability theory, with a brief introduction to stochastic processes, primarily Markov chains.

## Graduate Students

2003+ : Ph.D. advisor for:
- Libo Xie (Sequential Monte Carlo Methods for Analysis of Stochastic Volatility Models)
- Sinjini Mitra (Probabilistic models for automatic face recognition)

1999-2005 : Ph.D. thesis committees for:
- Sotirios Damouras (Gaussian processese for functional coefficient autoregressive models)
- Jeff Liebner ("Markov Models for Neuronal Spike Trains")
- Mihaela Serban (Multivariate stochastic volatility models and the market price of volatility risk)
- Ricky Rhambarhat ("Valuation Methods for American Derivatives in a Stochastic Volatility Framework")

• Calvin Yeung ("Modeling and Performance Analysis of Real-Time Queueing Networks")
• Michele DiPietro ("Bayesian Inference for Discretely Sampled Diffusion Processes with Financial Applications")
• Cristian Ghiuvea ("Pricing of Generalized American Options with Applications to Energy Derivatives")
• Ratish Punnoose (Electrical and Computer Eng., CMU, "Analysis of mutual interference between wireless devices")
• Philip Lee ("The Generalized Lambda Distribution Applied to Spot Exchange Rates")
• David Algranati ("Exploring Racial and Geographical Effects in the Decision to Seek the Federal Death Penalty, 1995-2000")
• Michelle Dunn ("Applying Particle Filter and Path-Stack Methods to Detecting Anomalies in Network Traffic Volume")
• Mingyu Cao (multi-antenna fMRI decoding algorithms)
• Yangang Zhang (Bayesian methods for mine detection)
• Manuela Buzoianu (sequential decision methods in medical trials)
• Taeryon Choi (Consistency of non-parametric Bayesian estimators)
• Aurora Bi (financial models for default risk)
• Liuxia Wang (model-based variable clustering in neurophysiology)
• Jeongeun Kim (Statistics Dept., Univ. of Pitt., stochastic volatility modeling)
• Mengzhi Wang (Computer Science Dept., CMU, analysis of hard-disk access times)
• Kary Myers (analysis of brain image data)
• Rhiannon Weaver (ACT-R cognitive models)
• Pedram Afshar (Robotics Dept., CMU, analysis of arm motion)
• Kinman Au (classification of galaxy structures)
• Jeff Palmer (analysis of oligonucleotide microarray data)

2000-2005 : Advanced Data Analysis project (similar to masters thesis) advisor for:
• Linqiao Zhao (primary advisor)
• Mihaela Serban (co-advisor)
• Alex Rojas (primary advisor)
• Manuela Buzoianu (primary advisor)
• Aurora Bi (co-advisor)
• Ricky Rhambarhat (primary advisor)
• Sesa Slavkovic (co-advisor)
• Philip Lee (primary advisor)

**Affiliations**

1997-2008 : member of I.E.E.E.

2000+ : member of Sigma Xi Society

2001-2008 : member of I.M.S., A.S.A.

**Miscellaneous Professional Service**

2007+ : Associate Editor, Electronic Journal of Statistics

2006-2008 : Associate Editor, Annals of Applied Statistics

2006 : NSF Grant Review Panel (CMG Program, July, Organizer: Rong Chen)

2006-2007 : President-Elect, Pittsburgh Chapter of the American StatisticalAssociation

2006 : Session organizer for Joint Statistical Meetings 2006: "Recent Developments in Monte Carlo Methods"

2005+ : Seminar Organizer, Dept. of Machine Learning, Carnegie Mellon University

2005+ : Faculty Senate Representative, Dept. of Statistics, Carnegie Mellon University

2004+ : Chair of Computing Committee, Dept. of Statistics, Carnegie Mellon University

1999-2003 : Member of Seminar Committee (Head of Committee, 2000-2003), Dept. of Statistics, Carnegie Mellon University

2004+ : Book Reviews:
- 3 books for Springer-Verlag
- 1 book for Wiley

1998+ : Reviewer for
- *Journal of the American Statistical Association*
- *Journal of Econometrics*
- *Journal of Computational and Graphical Statistics*
- *Computational Statistics and Data Analysis*
- *Journal of Business and Economic Statistics*
- *Statistics in Medicine*
- *Journal of Neurophysiology*
- *Biometrika*
- *Psychometrika*
- *Communications in Statistics*
- *NETWORK: Computation in Neural Systems*
- *Systems and Control Letters*
- *Asian Journal of Control*
- *Metrika*
- *IEEE Trans. on Signal Proc.*

## Computing Skills

| | |
|---|---|
| O.S. | : Windows, Linux |
| Prog. | : HTML, Python, Fortran, R/S-Plus, Matlab, basic Unix scripts, C, C++, C# |
| Libraries | : MPI (parallel programming), LAPACK (linear algebra), BLAS (vector/matrix routines), Gtk (Graphical Interface), .NET |

## Software Developed

| | |
|---|---|
| 2007+ | : For in-house use at Horton Point LLC: Multiple mathematical and statistical analysis libraries, several complete tick-based execution strategies, multiple alpha-generating strategies |
| 2005+ | : **Cronos**: open source time-series analysis package (`www.codeplex.com/cronos`), with graphical interface, handling ARMA/ARIMA/ARFIMA, GARCH and stochastic volatility models (includes complete libraries for analysis of these models) |
| 2005+ | : Real-time particle filter decoding module for brain control of a virtual reality cursor by a monkey (for Schwartz Lab at Univ. of Pittsburgh Dept. of Neurobiology, not publically available) |
| 2002 | : Code for automatic "parallelization" of Markov chain Monte Carlo simulation (see *Software Review: A Library for Regenerative MCMC Simulation*, ISBA Bulletin, 2002) |
| 1999 | : MS-Windows based semi-WYSIWIG Tex/Latex editor |
| 1998 | : Stochastic differential equation solution simulator |