Curriculum Vitae

Roy L. Streit, Ph. D.

Research Interests:

- Missing data statistical models for tracking, detection, and classification
  - Intensity filters for multi-target multi-sensor tracking
  - Multitarget tracking in remotely-sensed, hyper-spectral imaging systems
  - Probabilistic methods for multi-sensor automation and data fusion
- Discrete-continuous multivariate parameter estimation
  - Non-homogeneous Poisson point processes for biomedical imaging
  - Bayesian inference networks for statistical learning of structure from data
  - Hidden Markov models for non-stationary time series
- Statistical methods for pharmacovigilance and business analytics

Education:

Ph. D. in Mathematics, University of Rhode Island, 1978
Dissertation: Upper Bounds for Ratios of L_p Norms on Finite Dimensional Spaces via Spectral Estimates
Major Advisor: Prof. James T. Lewis

M. A. in Mathematics, University of Missouri, Columbia, 1970

B. A. (Honors) in Physics and Mathematics, East Texas State University, 1968

NSF Undergraduate Research Program, Stevens Institute of Technology, Hoboken, Summer, 1968

Professional Positions and Concurrent Appointments:

2005 – Present	Senior Scientist Metron, Reston, VA
2000 – 2005	Senior Technologist in the Senior Executive Service (SES) Naval Undersea Warfare Center (NUWC), Newport, RI
1970 – 2000	Mathematician, Naval Undersea Warfare Center, Newport, RI

2006 – Present	Adjunct Professor, Electrical and Computer Engineering Dept.
2001 – 2003	University of Massachusetts – Dartmouth
1990 (July)	Visiting Scientist, SACLANT Undersea Research Center La Spezia, Italy
1989 (Feb – Apr)	Visiting Scientist, Statistics Department Adelaide University, Adelaide, Australia
1987 – 1989	Exchange Scientist, Marine Studies Composite, Defence Science and Technology Organisation, Adelaide, Australia
1996 – 2001	Adjunct Professor, Mathematics Department
1982 – 1986	University of Rhode Island
1982 – 1984	Visiting Scientist, Computer Science Department Yale University, New Haven, CT
1981 – 1982	Visiting Scholar, Department of Operations Research Stanford University, Stanford, CA

Research Activities and Accomplishments:

2005 – Present: *Intensity filters for multitarget multisensor tracking and special topics*
Dr. Streit is a Senior Scientist at Metron, which he joined in April 2005. He is the Principal Investigator of several data fusion and target tracking programs. His primary research interests include multi-target tracking, multi-sensor data fusion, and distributed systems. His most recent work is the discovery of the surprising connections between PET (positron emission tomography) for medical imaging and multitarget tracking using intensity filters. This connection clarifies and enhances the understanding of the multi-target model used in PHD (probability hypothesis density) filters. This understanding also reveals the connection between SPECT (single photon emission computed tomography) and the multi-sensor intensity filter. His most recent work is on hybrid methods that combine PHD/Intensity filters and cumulative loglikelihood ratio detectors. Other related work includes multistatic active sonar tracking using multi-sensor intensity filters, a novel likelihood function decomposition method for tracking in heterogeneous sensor fields, a multi-frame multitarget tracking algorithm for the Ballistic Missile Defence (BMD) Program, and the application of support vector machines and machine learning methods to discriminate lethal and non-lethal objects for BMD.

He recently published a book entitled *Poisson Point Processes – Imaging, Tracking, and Sensing*, Springer, New York, 2010. He was elected to serve a three year term (2009 – 2011) on the Board of Directors of the International Society for Information Fusion (ISIF). He is currently President-Elect of ISIF and will serve as its President in 2012.

2000 – 2005: *Submarine sonar automation and multi-sensor data fusion*
This leadership position in the SES (Senior Executive Service) at NUWC required joint project and research leadership capabilities. Selected accomplishments include:

Invented the multi-target Spectral Precision Tracker (SPT), the first passive sonar tracker designed to simultaneously estimate trajectories and spectra of poorly resolved, spatially overlapped contacts. Demonstrated SPT capability on real sonar data for four major submarine sonar arrays. Led a product

development team to build and transition SPT into real-time tactical sonar systems for the Advanced Submarine Technology Office (ASTO) under the Advanced Processing Build – Acoustics (APB-Acoustics) Program.

Fundamentally altered the discussion of state-of-the-art Submarine Combat Systems capabilities for the Navy and the "Navy After Next." Proposed and led the State Estimation and Analysis using Multi-sensor Associated Spectral Tracks (SEAMAST) program for automated multi-sensor, multi-target data fusion for the submarine tactical control center. SEAMAST is highly innovative – it employs spectral data in tactical control and supported a critical re-examination of the fundamental architecture of the overall tactical control center. SEAMAST methods for automation and seamless data fusion supports the vision of reduced manning and quantum improvements in tactical picture generation time. Led a results-driven investigative team to demonstrate SEAMAST capabilities. SEAMAST was supported by NAVSEA under two programs (Acoustics and Tactical) and by ONR.

Led a highly inter-disciplinary team to design large structural-acoustic arrays for optimal beam-level detection. Evaluated the source-to-hydrophone spectral Green's function using finite element methods and incorporated it into a statistical model of detection at the beamformer output. Demonstrated the approach on an idealized problem using successive quadratic programming optimization to maximize the detector's deflection coefficient; approach validated on real data.

1992 – 2000: *Missing data methods and Probabilistic Multi-Hypothesis Tracking (PMHT)*
This research studied novel applications of statistical "missing data" methods to treat assignment problems. Such problems arise frequently in speech recognition, image analysis, intelligent autonomous control, and multi-target tracking. In the latter field, the assignment problem arises when measurements from multiple targets are available, but which measurements correspond to which target is unknown. This problem is NP-complete. By treating measurement-to-target assignments as missing data, the problem converts to a discrete-continuous estimation problem amenable to the EM method. The resulting algorithm, called the PMHT algorithm, has iterations of only *linear* complexity.

PMHT is highly original in its use of Bayesian inference networks and conditional independence graphs to model an "observer" state that comprises target tracks and measurement-to-target assignments. The CNRS sponsored a Paris workshop devoted to these and related methods in 1998, and the IEE sponsored a similar workshop held in London in 1999. PMHT has been investigated for diverse applications, including: ground moving target indicator (GMTI) radar problems, video "structure from motion" studies, robot path planning, and tracking subatomic particles.

1997 – 2000: *Special topics in statistical inference and numerical optimization*
Proposed, demonstrated, and published a novel method for fusing geometric data from sensors with disparate observability properties (e.g., sonobuoy detections and line array conical bearings) together with state space constraints (e.g., bathymetry). Exploited the method to partially compensate for environmental uncertainty. Missing data are posited which, together with the measured data, gives full observability. The measurement density is the integral over the missing data, and estimators derived using the EM method. This approach was applied to a classical triangulation and bearings-only target motion analysis problem — the missing data are ranges, and the estimator is an iteratively re-weighted linear least squares algorithm. Other research activities included an investigation of spatially non-homogeneous Poisson processes as source models for linear systems. The particular application analyzed the loss in detection performance of an acoustic array in the presence of multiple interferers whose number and locations are continually changing. The model was used to derive closed form correction terms to the classical recognition differential.

1989 – 1992: *Probability and its connections to artificial neural networks and data fusion*
Conducted research on the implications of probabilistic methods for artificial neural networks, then newly proposed by the artificial intelligence community for classification and control. I was among the first to show that feed-forward neural networks cannot outperform the optimal Bayesian classifier. The proof was constructive and used probabilistic mixtures. The non-trivial problem of efficiently estimating, or training, the mixture approximation on small training sets was solved using a maximum likelihood algorithm, derived via the EM method, coupled with cross-class data pooling. This work was the first to use tolerance intervals to quantify classification performance in bootstrapping trials. Five U.S. patents were granted for this and related research.

One of the first to propose and use Bayesian inference networks and conditional independence graphs for data fusion and for reasoning under uncertainty. These networks later became the theoretical basis for a multi-year ONR research program (1991 to 1999) on acoustic data fusion.

1986 – 1989: *Seamless target detection and tracking*
Research on automatic tracking and detection of time-varying frequency lines resulted in the first application of hidden Markov models (HMM's) to tracking. By including a null state in the Markov chain, the HMM tracker has the unique ability to initiate and terminate tracks automatically as an intrinsic part of the tracking algorithm. Detection algorithms designed specifically for time-varying lines were investigated, and their false alarm and false dismissal statistics were analyzed.

Continuous-state HMM's were shown to generalize the Kalman filter, that is, the Kalman filter is a specialized HMM, a fact still not widely appreciated today. This work was conducted jointly with Dr. Ross Barrett and other senior Australian research scientists while I was an Exchange Scientist at DSTO participating in their program for automatic detection, tracking, and classification.

1984 – 1987: *Special topics in linear systems and signal processing*
This exciting and transformational period led to an appreciation of the importance of integrating theory with practice whenever possible. Deeply involved in diverse applied mathematical analyses and research directly related to innovative acoustic towed array applications. Expanded earlier research on solving the general H_∞ robust control problems to develop an algorithm to compensate *in-situ* for failed sensors in a sensor array; taken to sea routinely for more than a decade and never observed to fail in practice.

Used a stochastic linear systems theory approach to analyze the effect of inter-channel crosstalk on beamformer performance, and validated this analysis for an optical TDM/WDM telemetry system. Used Fourier analysis methods to derive theoretical performance bounds for arrays comprised of sensors with large, spatially variable sensitivity, and to design optimal discrete and continuous groups for low array self-noise. Several of these algorithms and designs are accepted as state-of-the-art. Three U.S. patents resulted from the work.

1982 –1984: *Preconditioners for iterative matrix solvers*
Conducted research on polynomial preconditioners and conjugate gradient algorithms to solve non-self-adjoint indefinite partial differential equations by finite differences. This research was the first use of a complex approximation algorithm to compute improved preconditioners for iterative algorithms for non-symmetric linear systems. The work was conducted jointly with Dr. Howard Elman, then at the Yale University Research Center for Scientific Computation.

1975 – 1983: *Large acoustic array beamformer design*
Significant work in acoustic arrays led to algorithms accepted as state-of-the-art. Examples include: Studied minimum-variance distortionless response adaptive array processing in turbulent boundary layer induced non-homogeneous noise fields. Design of optimal conformal acoustic arrays with large impedances between elements. Derived theoretical performance bounds for arrays of sensors with spatially-variable sensitivity. Designed discrete and continuous sensors for low array self-noise. Three U.S. patent allowances resulted from these investigations.

1980 – 1983: *Large-scale linear programming and optimization*
Research on cutting plane methods for complex approximation culminated in the first published algorithm for the numerical solution of constrained systems of complex-valued linear equations in the Chebyshev (minimax) norm. This problem is important in several scientific areas, and it lead to the first published algorithm for solving general H_∞ robust control problems. The work was conducted at Stanford University in the Systems Optimization Laboratory of the Operations Research Department.

1972 – 1979: *Applications of approximation theory*
Initiated research interest in approximation theory and optimization during this period. In a series of small research projects, used ideas from Haar systems to formulate new design concepts for

beamforming acoustic arrays. This applied research motivated the questions that led to a dissertation topic in a specialized area of complex analysis known as Nikolskii inequalities.

Professional Honors:

2011 President-Elect for 2012, International Society for Information Fusion (ISIF)
2009 Elected to Board of Directors of ISIF
2001 Department of the Navy Superior Civilian Achievement Award
2001 University of Rhode Island Alumni Award
… for contributions to Science and Technology
2001 NUWC Distinguished Chair in Sonar Signal Processing
1999 Solberg Award, American Society of Naval Engineers
… for significant contributions to naval engineering through personal research performed within the three year period 1997-1999
1997 Scientist of the Year, Naval Sea Systems Command
1996 Project Award for Scientific Excellence, Naval Undersea Warfare Center
… for contributions to automatic detection and classification of transient acoustic signals

Professional Service and Activities:

President-Elect for 2012 and member of the Board of Directors since 2009
International Society for Information Fusion

Research Colleague: 2002, 2001, 1987, 1986, 1985
Collaborative research with visiting professors in the Summer Faculty Research Program; sponsored by Office of Naval Research and the American Society of Engineering Education

External Examiner of Ph.D. Theses
Victoria University of Wellington, New Zealand, Department of Computer Science: 6/10
University of Rhode Island, Department of Electrical Engineering: 5/97, 12/98, 5/99
Université de Rennes 1, France, Department of Engineering Science: 9/97
The Australian National University, Australia, Department of Systems Engineering: 4/96

Technical Program Committee Member
NATO Research Technology Initiative, Sensors and Electronics Technology Panel Symposium, Budapest, October 2003

Member, The Technical Cooperation Program (TTCP), Maritime Systems Group, Panel 9 - Sonar Technology, 1996 - 2005. (TTCP sponsors international defense scientific exchange and research between US, UK, Canada, Australia, and New Zealand.)

Guest Editor of theme issues of the U.S. Navy Journal on Underwater Acoustics
Data Fusion and Automation Technology, January 2000
Multi-Source Acoustic Data Fusion, July 1995

Member of the Underwater Acoustics Signal Processing Committee
IEEE Signal Processing Society, 1995 - 1999

Session Chair, multiple national and international conferences and symposia

Proposal Reviewer
National Science Foundation
Australian Research Foundation

Journal manuscript Reviewer
IEE Proceedings on Radar, Sonar, and Navigation
IEEE Transactions on Aerospace and Electronic Systems
IEEE Transactions on Signal Processing
Journal of the Acoustical Society of America
U.S. Navy Journal on Underwater Acoustics
IEEE Oceanic Engineering
IEEE Transactions on Neural Networks
SIAM Journal on Scientific and Statistical Computing
IEEE Transactions on Antennas and Propagation
Journal of Computational and Applied Mathematics
IEE Proceedings (UK)
IEE Signal Processing (UK)
Mathematical Programming

Professional society memberships
Society of Industrial and Applied Mathematics
Institute of Electrical and Electronic Engineers (IEEE) – Senior Member
Acoustical Society of America
American Society of Naval Engineers – Life member

Teaching Experience:

Mentoring graduate students in Ph.D. programs at NUWC and in Australia
Informal, 1982 - 2005

University of Rhode Island, Graduate School, 1998
Department of Electrical Engineering
Graduate course ELE/Math 575, Approximation Theory and Signal Processing
Standard material, but including Expectation-Maximization method and Gaussian mixtures

University of Connecticut, Graduate School, 1993
Department of Electrical and Systems Engineering
Graduate course EE 362, Estimation and Filtering Theory
Standard material, but including conditional independence graphs

University of Connecticut at Avery Point, Undergraduate Program, 1980 – 1981
Mathematics Department
First year calculus sequence

University of Missouri, Mathematics Department, 1968 – 1970
— Teaching Assistantship, two undergraduate courses per semester.
Courses included matrix algebra and the simplex method for linear programming, pre-calculus algebra, and business mathematics
— Department tutor for severely physically handicapped students,
An innovative and farsighted state funded program for quadriplegics

Publications

Summary statistics:

United States Patents: 9

Books: 3
— *Poisson Point processes: Imaging, Tracking, and Sensing*, Springer, New York, 2010. (ISBN 978-1-4419-6922-4)
— *Probabilistic Multi-Hypothesis Tracking and Related Topics*, NUWC Scientific and Engineering Volume, 1998.
— *Beamforming, Tracking, Neural Networks, and Mathematics*, NUWC Scientific and Engineering Volume, 1991.
(DTIC Accession Number ADA255574)

Research papers:	
— Refereed journals	28
— Other refereed papers and book chapters	10
Invited and contributed research papers:	
— With published conference proceedings	53
— With published abstracts	9
Other papers and presentations:	24
Research Seminars and Colloquia:	18

Citation counts of selected papers *(Google Scholar, July 2011)*:

144 … 1994, Vol. NN-5, p. 764, IEEE Trans. Neural Networks
"Maximum likelihood training of probabilistic neural networks"

119 … 1994, Vol. 2235, p. 394, SPIE Int'l Symp. on Sig. & Data Proc. of Small Targets
"Maximum likelihood method for probabilistic multi-hypothesis tracking"

108 … 1990, Vol. ASSP-38, p. 586, IEEE Trans. Acoust., Speech, and Sig. Proc.
"Frequency line tracking using hidden Markov models"

51 … 1982, Vol. 72, p. 181, J. Acoust. Soc. Am.
"A general Chebyshev complex function approximation procedure and an application to beamforming"

Government Technical Reports and Memoranda	157