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Title: Research in Stochastic Processes

Co-Principal Investigators: Professor Stamatis Cambanis

Professor Raymond J. Carroll

Professor Gopinath Kallianpur

Professor M. Ross Leadbetter

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Department of Statistics

University of North Carolina

Chapel Hill, North Carolina 27514

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19. ABSTRACT (Continue on reverse if necessary and identify by block number)
Four principal investigators and numerous visitors were supported by this contract at the Center for Stochastic Processes. Three of the principal investigators worked in various areas of stochastic processes. Their research and that of their collaborators addressed the following topics: (1) nonlinear systems with random inputs; (2) non-Gaussian signal processing; (3) digital processing of analog signals; (4) finitely additive nonlinear filtering; (5) Feynman integrals; (6) multiple stochastic integrals; (7) Dousker's delta functional; (8) extremal theory under higher local dependence; (9) high level exceedances by stationary point processes; and (10) estimation for stochastic processes. The fourth principal investigator carried out research in robust estimation for linear models. Topics addressed, also included: (1) robust and diagnostic transformation methods; (2) correcting for measurement error in logistic regression; (3) power transformations when fitting theoretical models to data; and (4) bounded influence estimation in heteroscedastic linear models.

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Dr. Robert T. Smythe	(0) 767- 5028	N

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CONTENTS

SUMMARY OF RESEARCH ACTIVITY

Research was conducted and directed in the area of stochastic processes by three of the Principal Investigators, S. Cambanis, G. Kallianpur, and M.R. Leadbetter, and their associates, and in robust estimation in statistical models by R.J. Carroll and co-workers. A summary of the main lines of activity in each area follows for each of the four Principal Investigators. More detailed descriptions of the work of all participants is given in the main body of the report.

STOCHASTIC PROCESSES

The research effort in stochastic processes was a major part of a substantial research activity organized as the Center for Stochastic Processes within the Statistics Department, involving permanent faculty, visitors and students. This organization has provided the framework for significant interaction between the participants--permanent and visiting. In addition the research program has been enhanced by a regular seminar series (listed by speakers later in the report) which has provided an excellent vehicle for exchange of current research ideas. The primary means for dissemination of results is the Center's Technical Report series, containing current research work prior to formal publication in journals. To date, 52 technical reports leading (or expected to lead) to published papers have been produced by the participants, involving research results in a wide area of stochastic process theory and applications. The main areas of research activity for each Principal Investigator and co-workers are as follows.

<u>S. Cambanis</u>. Nonlinear systems with random inputs: quadratic forms in stable random variables. Non-Gaussian signal processing: interpolation for harmonizable stable processes; ergodic properties of stationary stable processes: decompositions of stable processes of Wold, Hida and Karhunen-Loève type; self-similar stable processes; asymmetric stable processes. Digital processing of analog signals: analysis of a delayed delta modulator: analysis of adaptive differential

pulse code modulation of a stationary Gauss-Markov input.

G. Kallianpur. Finitely additive nonlinear filtering: the unbounded case; measure-valued equations for the optimum filter; the Markov property of the filter. Limit theorems in finitely additive probability. Stochastic problems in neurophysiology: infinite dimensional stochastic differential models for spatially distributed neurons. Diffusion approximations to the Boltzmann equation. Weak convergence of semimartingales. Filtering in Computer Axial Tomography. Feynman integrals: analytic and sequential Feynman integrals and a Cameron-Martin formula. Generalized Brownian functionals: Donsker's delta functional. Multiplicity theory. Doubly stochastic time series models.

M.R. Leadbetter. Extremal theory: extremes and local dependence in stationary sequences; extremes in dependent sequences, continuous stochastic processes, and for moving average processes; iterated logarithm laws for extremes of normal sequences. Point processes of exceedances: compound Poisson limit theorems for high level exceedances by stationary sequences; point processes associated with extremes of random sequences. Estimation for point processes: maximum likelihood estimation in the multiplicative intensity model. Estimation and structure for stochastic processes: probability density estimation for stationary sequences and processes; martingale central limit theory.

ESTIMATION IN LINEAR AND NONLINEAR MODELS

R.J. Carroll. Transformation and regression: power transformation and prediction; robust and diagnostic transformation methods; transformations for nonlinear regression; estimating the mean after transformation. Heteroscedastic linear models: bounded influence estimation in heteroscedastic models; non-constant variances; diagnostics for heteroscedastic models. Binary regression: nonnormality of maximum likelihood in functional measurement error models; estimation for binary measurement error models; diagnostics in logistic regression; bounded influence

estimators for logistic regression; applications of convexity in binary regression. Nonparametric density and regression function estimation: jackknifing; optimal bandwidth selection; cross validation; moments of kernel estimators; error criteria for comparisons among different estimators; mean integrated squared error approximations. Miscellanea: estimating a population size; managing a stochastic population; applying stochastic approximation to final optimal strategies; stochastic approximation in Monte-Carlo studies.

RESEARCH IN STOCHASTIC PROCESSES

STAMATIS CAMBANIS

The work briefly described here was developed in connection with problems arising from and related to the statistical communication theory and the analysis of stochastic signals and systems, and falls into the following three broad categories:

(I)   Nonlinear systems with random inputs,

(II) Non-Gaussian signal processing,

(III) Digital processing of analog signals.

Item 3 below belongs to category (I), and is the first stage of a joint effort with W. Woyczynski into the nonlinear analysis of stable signals, an area where very little work has been reported in the literature to date. Items 4,5, and 7 belong to category (II) and represent continuing work in the area of non-Gaussian stable processes, some joint with C.D. Hardin and A. Weron. Items 1 and 2 belong to category (III), and are joint with my former student, N. Gerr. Continuing work on sampling designs for time series, belonging to category (III) and some of it joint with E. Masry, will be included in next year's report.

1.   Analysis of a delayed delta modulator [1]

Delayed Delta Modulation (DDM) uses a second feedback loop in addition to the standard DM loop. While the standard loop compares the current predictive estimate of the input to the current sample, the new loop compares it to the upcoming sample so as to detect and anticipate slope overloading. Since this future sample must be available before the present output is determined and the estimate updated, delay is introduced at the encoding.

The performance of DDM with perfect integration and step-function reconstruction is analyzed for each of three inputs. In every case, the stochastic stability of the system is established. For a discrete time i.i.d. input, the (limiting) joint distribution of input and output is derived, and the (asymptotic)

mean square sample point error MSE(SP) is computed when the input is Gaussian. For a Wiener input, the joint distribution of the sample point and predictive errors is derived, and MSE(SP) and the time-averaged MSE (MSE(TA)) are computed. For a stationary, first-order Gauss-Markov input, the joint distribution of input and output is derived, and MSE(SP) and MSE(TA) computed. Graphs of the MSE's illustrate the improvement attainable by using DDM instead of DM. With optimal setting of parameters, MSE(SP) (MSE(TA)) is reduced about 15% (35%).

2. Analysis of adaptive differential PCM of a stationary Gauss-Markov input [2]

An Adaptive Matched Differential Pulse-Code Modulator (AMDPCM) is analyzed. The adaptation of the symmetric uniform quantizer parameter Δ_n is performed by fixed multipliers assigned to the quantizer output levels. The input is stationary first-order Gauss-Markov. The correlation of the samples is used as the leakage parameter in the matched integrator, with the predictive reconstruction similarly matched.

We examine the stochastic stability of this system when the range of Δ_n is unconstrained. For a 4-level quantizer and multipliers (γ^{-1}, γ) we derive the limiting joint distribution of the predictive error and Δ_n, and compute and plot the asymptotic sample point and time-averaged mean-square-error (MSE) and mean and variance of Δ_n as functions of $\gamma \in [1,2]$. We find that the asymptotic performance of AMDPCM does not depend on the choice of Δ_0, that the increase in MSE incurred by using A(M)DPCM instead of (M)DPCM with Δ_{opt} is small, with MSE(S(M)DPCM) $\downarrow$ $\min_\Delta$ MSE((M)DPCM) as $\gamma \downarrow 1$, and that the signal-to-noise ratio of AMDPCM does not depend on the input power.

3. Convergence of quadratic forms in stable random variables [3]

Necessary and sufficient conditions are given for the almost sure convergence of the quadratic form $\sum\sum f_{jk} M_j M_k$ where (M_j) is a sequence of independent

and identically distributed stable random variables. A connection is established between the convergence of the quadratic form and a radonifying property of the infinite matrix operator (f_{kj}). This work is an essential step in studying double Wiener integrals of a stable motion.

4. Ergodic properties of stationary stable processes [4]

Using their description developed in [5], we derive necessary and sufficient conditions for stationary symmetric stable processes to be ergodic or mixing and to satisfy a weak or strong law of large numbers. For ergodic stationary stable processes, we show how to estimate its covariation function, which plays a role analogous to that of the covariance in the Gaussian case. We then consider some important special classes of stationary stable processes. We show that sub-Gaussian stationary processes are never metrically transitive, and we identify their ergodic decomposition. Stable moving averages are shown to be mixing, and stationary stable solutions of stochastic differential equations are shown to be strongly mixing. Stationary stable processes with a harmonic spectral representation are never metrically transitive, in sharp contrast with the Gaussian case, and some intriguing facts concerning their ergodic decomposition are derived. Also stable processes with a harmonic spectral representation satisfy a strong law of large numbers even though they are not generally stationary.

5. Decomposition of stable processes [6]

Several kinds of decompositions of symmetric stable processes have been under study: (i) Wold-type decompositions into two orthogonal components of which one is deterministic and the other purely non-deterministic; (ii) Hida-type multiplicity decompositions for purely nondeterministic processes; (iii) Karhunen-Loeve type decompositions. The decompositions of type (i) are discussed in item no. 3 under C. Hardin and those of type (ii) in item no. 3 under A.

Weron. Here we discuss briefly the decompositions of type (iii).

It is shown that every stable process can be decomposed "uniquely" into two independent stable components of which one is "diffuse" and the other "discrete" (in the sense that it has a series expansion into independent stable terms). This is in sharp contrast with the Gaussian case where the diffuse components are always essentially trivial. Some special cases of interest are the following: Sub-Gaussian stable processes are always "diffuse." Stable processe with a harmonic spectral representation may have nontrivial "diffuse" and iscrete" components. Also necessary and sufficient conditions are given fo stable process to be "diffuse" or "discrete."

6. Preservation of stability by a random linear system [7]

When the random input process to a linear system is stable, then so is the output. This is no longer true if the linear system is also random (independently distributed from the random input). We have characterized the time invariant linear random systems which transform a stable white noise input to a stable output process: When the white input noise is Gaussian, the amplitude of the transfer function of the system is nonrandom and thus all the randomness of the system is in the phase of its transfer function. When the white stable input noise is non-Gaussian, the impulse response of the system is a random time shift of a nonrandom system multiplied by a random global sign.

7. Self-similar stable processes

A new class of self-similar stable processes has been introduced, distinct from the one introduced in [8] and [9]. Moreover the method used points a way of introducing further classes of self-similar stable processes. It may even be possible to characterize all self-similar stable processes. Also, by using multiple Wiener integrals of stable motions, further classes of self-similar processes will be introduced which will be nth order forms of stable processes.

References

1. N.L. Gerr and S. Cambanis, Analysis of a delta modulator, manuscript submitted for publication.

2. N.L. Gerr and S. Cambanis, Analysis of adaptive differential PCM of a stationary Gauss-Markov input, manuscript submitted for publication.

3. S. Cambanis, J. Rosinski and W. Woyczynski, Convergence of quadratic forms in p-stable random variables and θ_p-radonifying operators, Center for Stochastic Processes Technical Report No. 41, October 1983.

4. S. Cambanis, C.D. Hardin and A. Weron, Ergodic properties of stationary stable processes, Center for Stochastic Processes Technical Report in preparation.

5. C.D. Hardin, On the spectral representation of symmetric stable processes, J. Multivariate Anal. 12, 1982, 385-401.

6. S. Cambanis, C.D. Hardin and A. Weron, Decompositions of stable processes of Wold, Hida, and Karhunen-Loeve type, Center for Stochastic Processes Technical Report in preparation.

7. S. Cambanis, Preservation of stability by a random linear operator, Center for Stochastic Processes Technical Report in preparation.

8. M.S. Taqqu and R.L. Wolpert, Infinite variance self-similar processes subordinate to a Poisson measure, Z. Wahrsch. verw. Geb., 62, 1983, 53-72.

9. M. Maejima, On a class of self-similar processes, Z. Wahrsch. verw. Geb., 62, 1983, 235-245.

G. KALLIANPUR

Research was carried out in the following areas:

1. **Finitely additive nonlinear filtering** (with R.L. Karandikar)

The systematic development of this new theory, begun last year, has been carried forward. Among new results discovered during this period are the following.

(i) The treatment of the case where the boundedness assumption is removed from the observation model. The boundedness of h in $dY_t = h(x_t)dt + dW_t$ in the conventional (i.e. the stochastic calculus) theory has been an obstacle for a long time and our results based on the finitely additive theory have been obtained under less restrictive conditions than those available in the stochastic calculus approach [1].

(ii) The case of infinite dimensional signal and noise processes has been investigated in detail. The conditional distribution (i.e. the nonlinear filter) has been shown to satisfy certain measure-valued integral equations in which the observation appears as a parameter. The uniqueness of the solution of the latter equations has been established under suitable conditions. This work extends--in the context of the finitely additive approach--the results of H. Kunita and J. Szpirglas (see [2]).

(iii) The most recent result obtained in this area is the proof of the Markov property of the nonlinear filter [3]. This appears to be the first nontrivial example of a continuous parameter Markov process defined on a finitely additive probability space.

Also two survey papers on the subject have been written: [4] as an invited talk and [5] as an invited paper.

2. **Stochastic problems in neurophysiology** (with R. Wolpert)

Continuing the work on diffusion approximations for a neuron model begun by Kallianpur [6], Kallianpur and Wolpert have investigated more realistic stochastic

models that take into account the spatial distribution of neurons. The model
is then that of a random field driven by a generalized Poisson process. The
membrane X of the neuron which was represented by a single point in [6], can be
taken to be a long cylinder or a smooth, compact d-dimensional manifold. The
surface of a neuron is modeled by $d = 2$ while $d = 3$ is suitable for modeling the
interior of organs such as the heart.

The voltage potential ξ is viewed as a random field or a stochastic process
taking vlaues in Φ', the dual of a suitably chosen countably Hilbertian nuclear
space. Stochastic differential equations governing ξ are obtained and diffusion
approximations to a Φ'-valued Ornstein-Uhlenbeck process have been derived. As
special cases follow some of the work of Wan and Tuckwell and of John Walsh on
similar problems. This work reported in [7] was presented at the Symposium on
Stochastic differential equations in infinite dimensional spaces held in May-
June 1983 at Louisiana State University and is soon to be published.

Kallianpur and Wolpert are now working on some neurophysiological problems
that lead to nonlinear infinite dimensional stochastic differential equations.
A simple physiological example of the latter is one that involves "reversal
potentials." These results are being prepared for publication.

3. Feynman integrals (with R.L. Karandikar and D. Kannan)

In continuation of the work on this subject of Kallianpur and Bromley [8],
analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces
have been defined and studied. Specialization to "path" integrals makes possi-
ble comparison with some of the latest work of Cameron and Storvick and of
Elworthy and Truman. In addition, a "Cameron-Martin" formula has been obtained
for both analytic and sequential Feynman integrals whose applications include
the case of the harmonic potential. A paper covering these results is being

prepared for publication [9].

4. <u>Donsker's delta functional</u> (with H.H. Kuo)

During a visit to Louisiana State University, Kallianpur worked on this problem with Professor Kuo. A rigorous definition of the delta functional is given based on Hida's theory of generalized Brownian functionals. An Ito formula has also been obtained. The results are now being written up for publication [10]. Kuo gave an invited talk on this subject at the Baton Rouge Conference already referred to.

5. <u>Strict sense multiplicity theory</u> (with D. Tjøstheim)

This work is reported under Professor Tjøstheim's work.

6. <u>Generalized Brownian functionals</u> (with T. Hida)

Kallianpur and Hida have been developing finite-dimensional approximations to generalized Brownian functionals so that Hida's theory [11] becomes more readily accessible to computations.

7. <u>Multiple stochastic integrals</u>

Victor Perez-Abreu, a graduate student, has been working under Kallianpur's guidance on: (i) developing a unified method for defining stochastic measures based on techniques of tensor product and symmetric tensor product Hilbert spaces as described in [12]; (ii) obtaining representations of L^2-functionals of vector-valued processes of independent increments with non-independent components; (iii) multiple stochastic integrals for Hilbert space and nuclear space-valued processes.

8. <u>Prediction and smoothing for continuous parameter processes</u>

Hans Hucke, a graduate student working under Kallianpur's guidance, is extending the finitely additive approach of [5] to problems of prediction and smoothing. The corresponding theory based on stochastic calculus is given in Pardoux [14,15].

9. <u>Estimation problems in stochastic processes</u>

Mr. Mauro Marquez, a graduate student working under Kallianpur's direction, is working on parameter estimation problems arising in stochastic differential equations and in abstract Wiener spaces.

10. <u>Weak convergence problems in infinite-dimensional stochastic processes</u>

Søren Kier Christensen (a graduate student) and Kallianpur are working on extensions of (a) Kallianpur and Wolpert's work on stochastic models in neuro-physiology [7] and (b) Miyahara's work on the Fokker-Planck equation and the infinite dimensional Ornstein-Uhlenbeck process [13].

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<u>References</u>

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1. G. Kallianpur and R.L. Karandikar, The nonlinear filtering problem for the unbounded case, Center for Stochastic Processes Tech. Rept. No. 33, June 1983, to appear in Stochastic Proc. Appl., 14, 1984.

2. G. Kallianpur and R.L. Karandikar, Measure-valued equations for the optimum filter in finitely additive nonlinear filtering theory, Center for Stochastic Processes Tech. Rept. No. 24, January 1983.

3. G. Kallianpur and R.L. Karandikar, The Markov property of the filter in the finitely additive nonlinear filtering theory, Center for Stochastic Processes Tech. Rept. No. 44, November 1983.

4. G. Kallianpur and R.L. Karandikar, A finitely additive white noise approach to nonlinear filtering: A brief survey, Center for Stochastic Processes Tech. Rept. No. 42, Nov. 1983, to appear in Proc. 6th Int. Symp. on Multivariate Analysis.

5. G. Kallianpur and R.L. Karandikar, Some recent developments in nonlinear filtering theory, Center for Stochastic Processes Tech. Rept. No. 38, July 1983, to appear in Acta Applicandae Mathematicae 1, (1984), 249-284.

6. G. Kallianpur, On the diffusion approximation to a discontinuous model for a single neuron, in Essays in Honour of Normal L. Johnson, P.K. Sen (ed.) North Holland, 1983, 247-258.

7. G. Kallianpur and R. Wolpert, Infinite dimensional stochastic differential equation models for spatially distributed neurons, Center for Stochastic Processes Tech. Rept. No. 31, May 1983, to appear in Proc. 1983 CBMS-NSF Regional Conference on Stochastic Differential Equations in Dimensional Spaces and Their Applications.

8. G. Kallianpur and C. Bromley, Generalized Feynman integrals using analytic continuation in several complex variables, Stochastic Analysis, M. Pinsky, ed., Marcel-Dekker, 1984,

9. G. Kallianpur, R.L. Karandikar, and D. Kannan, Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces and a Cameron-Martin formula, Center for Stochastic Processes Tech. Rept. in preparation.

10. G. Kallianpur and H.H. Kuo, Regularity property of Donsker's delta function, Center for Stochastic Processes Tech. Rept. No. 51, Dec. 83, to appear in Proc. 1983 CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications.

11. T. Hida, Generalized Brownian functionals, Theory and Application of Random Fields, G. Kallianpur, ed.., Lecture Notes in Control and Information Sciences, No. 49, Springer-Verlag, 1983.

12. G. Kallianpur, Stochastic Filtering Theory, Springer-Verlag, New York, 1980.

13. Y. Miyahara, Infinite dimensional Langevin equation and Fokker-Planck equation, Nagoya Math. J., Vol. 81, (1981), 177-223.

14. E. Pardoux, Stochastic partial differential equations and filtering of diffusion processes, Stochastics 2, 127-168, (1979).

15. E. Pardoux, Smoothing of a diffusion process conditioned at final time, Proc. 2nd Bad Honnef Conference on Stochastic Differential Systems, M. Kohlmann, ed., Lecture Notes in Control and Information Sciences, No. 43, Springer-Verlag, (1982).

M.R. LEADBETTER

Research was conducted in three areas during the reporting period: (a) continued effort in extremal theory for stochastic processes with higher local dependence, (b) associated problems for related point processes and (c) function estimation problems for stationary processes. The direction of effort and resulting publications are described below.

1. Extremal theory under higher local dependence

Work reported in [1] and [2] concerned the existence of an "extremal index, θ" describing the effect of increased local dependence in a stationary sequence, on the asymptotic distribution of the maximum of a stationary sequence. This work has been revised and extended and is to be published in [3] and [4]. In particular it has been shown that the introduction of high local dependence is, in all cases of practical interest, simply to replace any asymptotic distribution G for the maximum by G^θ. The effect of this dependence on the distribution of order statistics is much more complicated and may be discussed from the work under 2.

2. Associated problems for related point processes

In the work reported in [3] and [4], some discussion was provided of the properties of high level exceedances by a stationary sequence, viewed as a point process. In particular it was shown that high local dependence leads to a clustering of the exceedances, the cluster centers becoming Poisson in character as the level increases.

A more detailed investigation for the exceedances themselves (rather than just the cluster centers) was undertaken, together with J. Hüsler and a student, T. Hsing. It was shown that in fact the "exceedance point processes" converge to a compound Poisson process under natural conditions. This result has the potential for describing the asymptotic distribution of order statistics as

well as that for the maximum discussed under 1. These results will be reported initially in [5].

Further results in this area obtained primarily by T. Hsing involve so-called "complete convergence" for a point process in the plane formed by the (normalized) sequence values themselves. The nature of any limiting point process has been discussed, generalizing previous work of Mori [6]. This work will be reported in a dissertation by T. Hsing [7] and resultant publications.

3. Estimation for stochastic processes

The work reported previously on estimation of point process intensities has been published in [8]. Further work has been undertaken with J. Castellana on probability density estimation for stationary sequences. A technical report [9] has been prepared and will be available in the near future. Journal submission of this work is also planned.

References

1. M.R. Leadbetter, Extremes and local dependence in stationary sequences, Center for Stochastic Processes Tech. Rept. No. 12, June 1982.

2. M.R. Leadbetter, G. Lindgren and H. Rootzén, Extremes and related properties of random sequences and processes, Springer Statistics Series, 1983.

3. M.R. Leadbetter, Extremes and local dependence in stationary sequences, to appear in Z. Wahrsch. verw. Geb., 1984.

4. M.R. Leadbetter, Extremes in dependent random sequences, Center for Stochastic Processes Tech. Rept. No. 34, June 1983. To appear in Proc. NATO ASI, J. Tiago de Oliveira, ed., Reidel, N.Y.

5. T. Hsing, J. Hüsler and M.R. Leadbetter, Compoung Poisson limit theorems for high level exceedances by stationary sequences, Center for Stochastic Processes Tech. Rept. in preparation.

6. T. Mori, Limit distributions of two-dimensional point processes generated by strongly mixing sequences, Yokohama Math. J. 25, 155-167, 1977.

7. T.Hsing, Point processes associated with extremes of stochastic sequences, Ph.D. dissertation under preparation.

8. M.R. Leadbetter and Diane Wold, On estimation of point process intensities, in Contributions to Statistics--Essays in Honour of Norman L. Johnson (P.K. Sen, Ed.), North Holland, 1983.

9. J.V. Castellana and M.R. Leadbetter, On smoothed estimation of probability densities for stationary processes, Center for Stochastic Processes Tech. Rept. under preparation.

N. DINCULEANU
(University of Florida at Gainesville)

Professor Dinculeanu spent one month at the Center in the summer. He is a well known expert on vector measures and now intends to do research in certain areas of stochastic processes. He has been going through Kallianpur's work on filtering theory, has discussed semimartingale theory and weak convergence of measures with Métivier (whose seminars he attended) and also had discussions with Karandikar on the finitely additive theory being developed by him and Kallianpur.

TADAHISA FUNAKI
(Nagoya University)

Dr. Funaki's research has been a continuation of his work on certain problems of statistical mechanics, specifically the study of diffusion approximations of the Boltzmann equation under various sets of hypotheses.

The Boltzmann equation is a fundamental equation in statistical mechanics. In [2], probabilistic methods are employed to investigate this equation. Stochastic processes are associated with the Boltzmann equation mainly in the case of a soft potential assuming spatially homogeneity. These processes are given by solving a kind of non-linear martingale problem with jumps. Then, the diffusion approximation of the Boltzmann equation is studied, which was investigated first by the physicist L.D. Landau in analyzing the time evolution of plasma. To complete the proof of the diffusion approximation mathematically one needs the uniqueness of solutions to a martingale problem associated with a certain kind of nonlinear diffusion equation. This kind of martingale problem is discussed in [1].

References

1. T. Funaki, A certain class of diffusion processes associated with nonlinear parabolic equations, Center for Stochastic Processes Tech. Rept. No. 43, November 1983.

2. T. Funaki, The diffusion approximation of the spatially homogeneous Boltzmann equation, Center for Stochastic Processes Tech. Rept. No. 52, December 1983.

CLYDE D. HARDIN
(University of Wisconisn-Milwaukee)

-Dr. Hardin continued his earlier work on stable processes in the following areas.

1. General (asymmetric) stable variables and processes [1]

While previous research in stable processes has dealt almost exclusively with symmetric stable processes, here we deal with stable variables and processes where the symmetry requirement has been dropped. Such "skewed" processes are clearly of wider applicability. Specifically, we determine the form of all strictly stable independent increments processes and develop a Wiener-type stochastic integral. We prove a generalization of the spectral representation theorem for symmetric stable processes to general stable processes: it says, loosely, that all stable processes are stochastic integrals with respect to a stable process with stationary, independent increments and "maximum skewness." With the aid of the representation, we solve some regression problems. For example, we show that the regression of one stable variable upon another is not always linear, in sharp contrast with the symmetric case. We determine necessary and sufficient conditions for its linearity and determine the regression function when it is not linear. Also, some decompositions of general stable distributions are given and some moment inequalities are proved.

2. Ergodic properties of stationary stable processes [2]

This research is described in item 4 under S. Cambanis.

3. Orthogonal decompositions of stable and pth-order processes [3]

As an analog to the usual Wold decomposition of second-order processes into a purely nondeterministic and an orthogonal deterministic component, we develop some theories of orthogonal and independent decompositions for processes with only pth moments $(0 < p < 2)$, paying special attention to the stable processes. The notion of orthogonality in L^p which we use is one due to

G. Birkhoff and popularized by R.C. James [4].

the situation is much more complicated than in the second-order case, owing mainly to the lack of symmetry in the orthogonality relation. We thus have possibilities for "left" and "right" orthogonal decompositions, according as the deterministic part is orthogonal to the purely nondeterministic part or vice-versa. One might also hope for an independent decomposition (as in the Gaussian case) for some processes.

It is shown that none of these decompositions is general in the sense that all pth order processes (or even stationary stable sequences) will have such a decomposition. Yet, in many nontrivial cases we may decompose the process in one way or another. We give conditions guaranteeing the existence of each decomposition, and characterize independent decompositions in the stable case. We also exhibit some specific examples illustrating the various decompositions and the difficulties with them.

References

1. C.D. Hardin, General (asymmetric) stable variables and processes, Center for Stochastic Processes Tech. Rept. in preparation.

2. S. Cambanis, C.D. Hardin and A. Weron, Ergodic properties of stationary stable processes, Center for Stochastic Processes Tech. Rept. in preparation.

3. S. Cambanis, C.D. Hardin and A. Weron, Decompositions of stable processes of Wold, Hida and Karhunen-Loève type, Center for Stochastic Processes Tech. Rept. in preparation.

4. R.C. James, Orthogonality and linear functionals in normed linear spaces, Trans. Amer. Math. Soc. 61, 1947, 265-292.

A.M. HASOFER

(University of New South Wales, Australia)

M. Hasofer conducted research in extreme value theory and probabilistic geo-technical engineering, during a short visit to the Center for Stochastic Processes. The following is an abstract of a paper written on the latter topic.

New and extended work in some areas of probabilistic geotechnical engineering are presented in a largely non-technical fashion. The areas covered are the following:

Measuring soil properties, including geostatistics; graphical analysis; choice of estimators; factor analysis and updating parameter distributions; Markov processes, including micro-macro models and progressive slope failure; and probabilistic design with special reference to Level II design methods and slope stability.

References

1. M. Hasofer, Recent developments in probabilistic geotechnical engineering, Center for Stochastic Processes Tech. Rept. No. 40, August 1983.

MARTIN JACOBSEN
(University of Copenhagen)

During a short visit, Martin Jacobsen conducted research in Markov Process theory (cf. [1]) and lectured on the martingale approach to point processes, with particular reference to the use of multiplicative intensities.

References

1. M. Jacobsen, Two operational characterizations of cooptional times, Stat. Mimeo Series, University of Copenhagen, Denmark.

D. KANNAN
(University of Georgia)

Dr. Kannan worked on Feynman integrals with G. Kallianpur and R.L. Karandikar. This work will be included in [1] and is described under Kallianpur's research.

Dr. Kannan has also used sequential Feynman integrals to study certain kinds of oscillatory integrals and obtained a series slightly more general than the usual Dyson series. Mr. Hazareesingh, a graduate student working under Professor Kannan's guidance, studied the properties of product integrals with respect to semimartingales.

References

1. G. Kallianpur, R.L. Karandikar, and D. Kannan, Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces and a Cameron-Martin formula, Center for Stochastic Processes Tech. Rept. in preparation.

R.L. KARANDIKAR
(Indian Statistical Institute)

Dr. Karandikar continued his research program in the following areas.

1. <u>White noise approach to nonlinear filtering</u> (with G. Kallianpur)

This work is included in [1,2,3,4,5] and is described under G. Kallianpur's research.

2. <u>Limit theorems in finitely additive probability</u>

Limit theorems for a sequence of random variables on a general finitely additive probability space are studied, and the following "general principle" is proved: a <u>limit theorem</u> is valid on a finitely additive probability space if and only if it is true on a countably additive probability space. As consequences, analogues of the strong law, the central limit theorem for independent and mixing random variables, martingale convergence theorems, the invariance principle for martingales, the ergodic theorem, and De Finetti's theorem on exchangeable sequences are derived on a finitely additive probability space. Also a version of Chatterji's subsequence principle is shown to be true on a finitely additive probability space. See [6].

3. <u>On Feynman integrals</u> (with G. Kallianpur and D. Kannan)

This work will be included in [7] and is reported under Kallianpur's research.

References

1. G. Kallianpur and R.L. Karandikar, The nonlinear filtering problem for the unbounded case, Center for Stochastic Processes Tech. Rept. No. 33, June 1983, to appear in Stochastic Proc. Appl., 14, 1984.

2. G. Kallianpur and R.L. Karandikar, Measure-valued equations for the optimum filter in finitely additive nonlinear filtering theory, Center for Stochastic Processes Tech. Rept. No. 24, January 1983.

3. G. Kallianpur and R.L. Karandikar, The Markov property of the filter in the finitely additive nonlinear filtering theory, Center for Stochastic Processes Tech. Rept. No. 44, November 1983.

4. G. Kallianpur and R.L. Karandikar, A finitely additive white noise approach to nonlinear filtering: A brief survey, Center for Stochastic Processes Tech. Rept. No. 42, Nov. 1983, to appear in Proc. 6th Int. Symp. on Multivariate Analysis.

5. G. Kallianpur and R.L. Karandikar, Some recent developments in nonlinear
      filtering theory, Center for Stochastic Processes Tech. Rept. No. 38,
      July 1983, to appear in Acta Applicandae Mathematicae 1, (1984), 249-
      284.

6. R.L. Karandikar, A general principle for limit theorems in finitely additive
      probability: The dependent case, Center for Stochastic Processes Tech.
      Rept. No. 37, July 1983.

7. G. Kallianpur, R.L. Karandikar, and D. Kannan, Analytic and sequential
      Feynman integrals on abstract Wiener and Hilbert spaces and a Cameron-
      Martin formula, Center for Stochastic Processes Tech. Rept. in prepa-
      ration.

ALAN F. KARR

(Johns Hopkins University)

Professor Karr conducted research on estimation in the "multiplicative density model" for point processes, reported in [1]. In this work the method of sieves is used to construct estimators of an unknown function appearing as a factor in the stochastic intensity of a point process. Even though the likelihood function is unbounded above, the estimators are constructed by maximizing the likelihood function over subsets of the index space. For submodels with finite-dimensional parameterizations, consistency and asymptotic normality of estimators constructed as solutions to likelihood equations are demonstrated. Finally a general contiguity theorem for multiplicative intensity processes is established.

Professor Karr also worked on the completion of Chapters 3-8 of a book [2] to be published by Marcel Dekker, Inc. The book is an in-depth unified treatment of the theories of point processes on general spaces and statistical inference for them, using both empirical process and martingale methods. In addition to general theories it contains detailed examinations of classes of point processes (e.g., Poisson processes and Cox processes) of special importance in applications.

References

1. A. Karr, Maximum likelihood estimation in the multiplicative intensity model, Center for Stochastic Processes Tech. Rept. No. 46, November 1983.

2. A. Karr, Point processes and their statistical inference, Marcel Dekker, 1985, to appear.

JACQUES DE MARÉ
(Chalmers University, Sweden)

During a short visit, Dr. de Maré conducted research related to extremal theory for stochastic processes with particular reference to properties of axis crossings. A paper written on this topic is now being revised to appear as a Technical Report.

WILLIAM P. McCORMICK
(University of Georgia)

Dr. McCormick continued his research in extremal theory for stochastic processes and related topics. This work is reported in the following papers.

1. **An iterated logarithm law result for extreme values from Gaussian sequences** [1]

Let $\{X_n, n \geq 1\}$ be a stationary Gaussian sequence with $EX_1 = 0$, $EX_1^2 = 1$ and $r_n = EX_1 X_{n+1}$. Let $Z_n^{(i)}$ denote the ith maximum of $X_1, \ldots, X_n$ and $a_n = (\ell n \ell n n)(2\ell n n)^{-\frac{1}{2}}$, $b_n = (2\ell n n)^{\frac{1}{2}} - (\ell n(4\pi \ell n n))/(2(2\ell n n)^{\frac{1}{2}})$. Then assuming $r_n(\ell n n)^2 = 0(1)$ the set of almost sure limit points of the vectors $((Z_n^{(1)} - b_n)a_n^{-1}, (Z_n^{(2)} - b_n)a_n^{-1}, \ldots, (Z_n^{(\ell)} - b_n)a_n^{-1})$ is determined. The number of components $\ell = \ell(n) \to \infty$ as $n \to \infty$. This extends a result of Hebbar.

2. **Weak and strong law results for a function of the spacings** [2]

Let $\{U_n, n \geq 1\}$ be i.i.d. uniform on $(0,1)$ random variables and define $S_{i,n} = U_{i,n-1} - U_{i-1,n-1}$, $i = 1, \ldots, n$ where the $U_{i,n-1}$ are the order statistics from a sample of size $n-1$ and $U_{0,n-1} = 0$ and $U_{n,n-1} = 1$. The $S_{i,n}$ are called the spacings divided by $U_1, \ldots, U_{n-1}$. For a fixed integer ℓ, set $M_{\ell,n} = \max_{1 \leq i \leq n-\ell} \min_{i \leq j \leq i+\ell} S_{j,n}$. Exact and weak limit results are obtained for the $M_{\ell,n}$. Further we show that with probability one

$$\lim_{n \to \infty} \frac{(\ell+1)nM_{\ell,n}}{\log n} = 1.$$

This extends results of Cheng.

References

1. W.P. McCormick, An iterated logarithm law result for extreme values from Gaussian sequences, Center for Stochastic Processes Tech. Rept. No. 29, March 1983. J. Appl. Probability, 1984, to appear.

2. W.P. McCormick, Weak and strong law results for a function of the spacings, Center for Stochastic Processes Tech. Rept. No. 30, May 1983.

MICHEL MÉTIVIER
(Ecole Polytechnique, Paris)

Professor Métivier had extensive and fruitful discussions in the following subject areas:

a) Stochastic integration, and in particular, stochastic integration in infinite dimensional spaces (discussions with Professors Kallianpur, Dinculeanu, Wolpert, Hida, Karandikar, Funaki).

b) Weak convergence of processes (discussions with the same people as in a)).

c) Stochastic approximation (discussions with Professors Ruppert and Cambanis).

Lecture notes on "Weak convergence of sequences of semimartingales" were written as a report [1]. They contain a new result concerning the weak compactness of sequences of Hilbert valued martingales. This result is now included in a bigger paper, "An invariant principle for Sobolev valued processes" which is available as a preprint. The main part of the lecture notes consists of material to be included in a forthcoming joint paper with Professor A. Joffe on "Weak convergence of processes and application to branching processes."

As to stochastic integration, discussions with Professor N. Dinculeanu gave the start to a new approach to the study (proof of a specific Ito formula) of processes of the form $M(t,Z_t)$, where $M(t,x)$ is a martingale indexed by the parameter x and Z_t is a semimartingale. This approach is based on an "integration by part formula" for cylindrical martingales on a Banach space.

Professor Métivier gave two series of seminars: 6 lectures on weak compactness of sequences of semimartingales, based on the lecture notes written at the same time (see [1]) and 3 lectures on stochastic approximation based on a paper to be published in the I.E.E.E. Transactions on Information Theory.

References

1. M. Metivier, Weak convergence of sequences of semimartingales, Center for Stochastic Processes Tech. Rept. No. 49, October 1983.

HOLGER ROOTZÉN
(University of Copenhagen)

Dr. Rootzén has conducted research in extremal theory, central limit theory, and estimation for stochastic processes. The following abstracts summarize results obtained during the reporting period.

1. Extreme value theory for moving average processes

This paper studies extreme values in infinite moving average processes $X_t = \sum_\lambda c_{\lambda-t} Z_\lambda$ defined from an i.i.d. noise sequence $\{Z_\lambda\}$. In particular this includes the ARMA-processes often used in time series analysis. A fairly complete extremal theory is developed for the cases when the d.f. of the Z_λ's has a smooth tail which decreases approximately as $\exp\{-z^p\}$ as $z \to \infty$, for $0 < p < \infty$, or as a power of z. The influence of the averaging on extreme values depends on p and the c_λ's in a rather intricate way. For $p = 2$, which includes normal sequences, the correlation function $r_t = \sum_\lambda c_{\lambda-t} c_\lambda / \sum_\lambda c_\lambda^2$ determines the extremal behavior while, perhaps more surprisingly, for $p \neq 2$ correlations have little bearing on extremes. Further, the sample paths of $\{X_t\}$ near extreme values asymptotically assume a specific nonrandom form, which again depends on p and $\{c_\lambda\}$ in an interesting way. One use of this latter result is as an informal quantitative check of a fitted moving average (or ARMA) model, by comparing the sample path behavior predicted by the model with the observed sample paths.

2. Extremes in continuous stochastic processes

The by now well developed extremal theory for stationary sequences, including the Extremal Types Theorem and criteria for convergence and domains of attraction, has interesting extensions to continuous parameter cases. One way of using discrete parameter results to obtain these extensions--this is the approach to be reviewed here--proceeds by the simple device of expressing the maximum over an expanding interval of length $T = n$, say, as the maximum of n "submaxima" over fixed intervals, viz $M(T) = \max\{\zeta_1, \ldots, \zeta_n\}$ where $\zeta_i = \sup\{\xi(t); i-1 \leq t \leq i\}$. The

proofs involve three main ingredients, (i) results on the tail of the distribution of one ζ, i.e. of the maximum over a fixed interval, (ii) mixing conditions: which limits the dependence between extremes of widely separated ζ's and (iii) clustering conditions; which specify the dependence between neighboring ζ's. Each of (i)-(iii) also involves rather elaborate "discretization" procedures to enable probabilities to be calculated from finite-dimensional distributions. Methods and results for the Gaussian case will be stressed, following extensive treatment in Part III of Leadbetter, Lindgren and Rootzén: Extremes and related properties of stationary sequences and processes, Springer (1983). Finally, alternative approaches will be briefly commented on.

3. Central limit theory for martingales via random change of time

This paper contains an exposition of the by now rather complete central limit theory for discrete parameter martingales providing new and efficient proofs. The basic idea is to start by proving a central limit theorem under quite restrictive conditions (that the summands tend uniformly to zero and that the sums of squares converge uniformly) and then to obtain the most general results by random change of time and truncation. The emphasis is on the sums of squares (or squared variation process), and Burkholder's square function inequality plays a crucial role in the development. In particular, this approach leads to a very short and direct proof of tightness. In the proofs we make much use of a result (Lemma 2.5) which is believed to be new and which binds together convergence to zero of sums and of sums of conditional expectations. In the final section, the results are extended to several dimensions, to mixing convergence, and to convergence to mixtures of normal distributions.

4. Consistency in least squares estimation: A Bayesian approach

In a previous paper, Sternby (1977), the convenience of using martingale theory in the analysis of Bayesian Least Squares estimation was demonstrated.

However, certain restrictions had to be imposed on either the feedback structure or on the initial values for the estimation. In the present paper these restrictions are removed, and necessary and sufficient conditions for strong consistency (in a Bayesian sense) are given for the Gaussian white noise case without any assumptions on closed loop stability or on the feedback structure.

In the open loop case the poles are shown to be consistently estimated, a.e. and in the closed loop case certain choices of control law are shown to assure consistency. Finally adaptive control laws are treated, and implicit self-tuning regulators are shown to converge to the desired control laws.

References

1. H. Rootzén, Extreme value theory for moving average processes, Center for Stochastic Processes Tech. Rept. No. 36, July 1983.

2. H. Rootzén, Extremes in continuous stochastic processes, to appear in Statistical Extremes and Applications, Proc. NATO-ASI, Tiago de Oliveira, (ed.), Reidel, New York.

3. H. Rootzén, Central limit theory for martingales via random change of time, Center for Stochastic Processes Tech. Rept. No. 28, February 1983, to appear in Probability and Math. Stat., Essays in Honour of Carl-Gustav Esseen, (A. Gut, L. Holst, eds.), Uppsala University, 1983.

4. H. Rootzén and J. Sternby, Consistency in least squares estimation: A Bayesian approach, Center for Stochastic Processes Tech. Rept. No. 48, November 1983.

S. TAKENAKA
(Nagoya University)

Dr. Takenaka worked on the application of the theory of Radon transforms to some linear filtering problems. He considers the problem of estimating linear functionals of a Gaussian random field, where the observation is its Radon transform, in the presence of additive Gaussian white noise. This work has applications to Computer Axial Tomography and has been reported in [1].

References

1. S. Takenaka, A linear filtering problem using Radon transform, Center for Stochastic Processes Tech. Rept. No. 45, October 1983.

DAG TJØSTHEIM
(University of Bergen)

Dr. Tjøstheim has been working on doubly stochastic time series models and also, jointly with G. Kallianpur, on some aspects of multiplicity theory.

1. Doubly stochastic time series models [1]

The object is to construct and study models for time series, where the generating mechanism (parameters) varies in time in a random manner. It is believed that these models will constitute a more realistic description for certain classes of time series occurring in practice than earlier models. Specifically, time series models are considered that are obtained by replacing the parameters of autoregressive models by stochastic processes. Special attention is given to the problem of finding conditions for stationarity and to the problem of forecasting. For the first problem we are only able to obtain solutions in special cases, and the emphasis is on techniques rather than obtaining the most general results in each case. For the second problem more complete results are obtained by exploiting similarities with discrete time (nonlinear) filtering theory. The methods introduced are illustrated on two standard examples, one of state space type, and one where the parameter process is a Markov chain.

2. Estimation in doubly stochastic time series models [2]

This project is a continuation of the work on doubly stochastic time series models started in [1]. In order to use these models in practice one must be able to estimate unknown parameters. Three estimation methods are considered, namely method of moments, conditional least squares and maximum likelihood. Under certain conditions it is shown that these estimates are consistent and asymptotically normal. Identification of models will also be considered.

3. Strict sense multiplicity theory

This project is joint with G. Kallianpur. One problem consists of trying to classify probabilistic structure of stochastic processes in terms of a certain self-adjoint operator associated with the process. Another problem is to try to use functional analytic techniques to obtain stochastic integral representations of functionals on the process.

References

1. D. Tjøstheim, Some doubly stochastic time series models, Center for Stochastic Processes Tech. Rept. No. 47, November 1983.

2. D. Tjøstheim, Estimation in doubly stochastic time series models, Center for Stochastic Processes Tech. Rept. in preparation.

ALEKSANDER WERON
(Now at Louisiana State University)

Dr. Weron of the Technical University of Wroclaw did research in various aspects of stable processes.

1. Harmonizable stable processes on groups: spectral, ergodic and interpolation properties [1]

This work extends to symmetric α-stable (SαS) processes, $1 < \alpha < 2$, which are Fourier transforms of independently scattered random measures on locally compact Abelian groups, some of the basic results known for processes with finite second moments and for Gaussian processes. Analytic conditions for subordination of left (right) stationarily related processes and a weak law of large numbers are obtained. The main results deal with the interpolation problem. Characterization of minimal and interpolable processes on discrete groups are derived. Also formulae for the interpolator and the corresponding interpolation error are given. This yields a solution of the interpolation problem for the considered class of stable processes in this general setting.

2. Ergodic properties of stationary stable processes [2]

This research is described in item 4 under S. Cambanis.

3. Hida type multiplicity representation for p-stable stochastic processes [3]

An analogue of Hida's canonical representation of Gaussian processes is obtained for a class of symmetric p-stable (SpS) processes, $1 < p < 2$. Every left-continuous, purely nondeterministic SpS process X_t, $-\infty < t < \infty$, which has the "independent projection" property can be expressed in the form

$$X_t = \int_{n=1}^{N} \int_{-\infty}^{t} g_n(t,u) dY_n(u)$$

where the Y_n's are mutually independent SpS processes with independent increments, $g_n(t,\cdot) \in L^p(dG_n)$, and the spectral functions $G_n(t)$ = Covariation of $Y_n(t)$ with $Y_n(t)$, satisfy the partial ordering relation of absolute continuity:

$G_1 > G_2 > ... > G_N$.   In contrast with the Gaussian case, purely nondeterministic stable processes which are Fourier transforms of processes with independent increments, have no multiplicity representation.

References

1. A. Weron, Harmonizable stable processes on groups: Spectral, ergodic and interpolation properties, Center for Stochastic Processes Tech. Rept. No. 32, June 1983.

2. S. Cambanis, C.D. Hardin and A. Weron, Ergodic properties of stationary stable processes, Center for Stochastic Processes Tech. Rept. in preparation.

3. S. Cambanis, C.D. Hardin and A. Weron, Decompositions of stable processes of Wold, Hida and Karhunen-Loève type, Center for Stochastic Processes Tech. Rept. in preparation.

R. WOLPERT
(Duke University)

1. <u>Stochastic problems in neurophysiology</u> (with G. Kallianpur)

   This work has been reported under Kallianpur's research and has produced [1]. The collaboration between Kallianpur and Wolpert is continuing even though Wolpert's official connection with the Center has ended.

2. <u>Statistical estimation of the mean of a Gaussian process and the Stein effect</u> (with J. Berger, Purdue University).

   The global problem of estimation of the mean of a quite general Gaussian process is considered. The usual minimax estimator is shown to be inadmissible via the Stein phenomenon. Estimators improving on the minimax extimator are constructed. The results have appeared in [2].

References

1. G. Kallianpur and R. Wolpert, Infinite dimensional stochastic differential equation models for spatially distributed neurons, Center for Stochastic processes Tech. Rept. No. 31, May 1983, to appear in Proc. 1983 Symp. on Stochastic Differential Equations in Infinite Dimensional space.

2. J. Berger and R. Wolpert, Estimating the mean function of a Gaussian process and the Stein effect, J. Multivariate Anal. 13, (1983), 401-424.

WOJBOR WOYCZYNSKI
(Case Western Reserve University)

During his one month summer visit, Dr. Woyczynski initiated with S. Cambanis the work which resulted in [1] and is described in item 3 under S. Cambanis. Further joint work will concentrate on double Wiener integrals of stable motions.

References

1. S. Cambanis, J. Rosinski and W.A. Woyczynski, Convergence of quadratic forms in p-stable random variables and θ_p-radonifying operators, Center for Stochastic Processes Tech. Rept. No. 41, October 1983.

RESEARCH IN ROBUST ESTIMATION IN LINEAR MODELS

RAYMOND J. CARROLL

During the past year, research has focused on the following areas: robust and diagnostic transformations; transformations in nonlinear regression models; robustness and diagnostics in linear regression models; robustness and diagnostics in logistic regression models; the effects of measurement error on logistic regression and corrections for this measurement error; estimating the size of a population.

Two Ph.D. Students, Leonard A. Stefanski and David M. Giltinan are completing their dissertations in December, 1983, under my direction. Dr. Wolfgang Härdle visited the first six months of 1983 and produced a number of reports on nonparametric density and regression function estimation. Dr. Brenton Clarke is visiting the last six months of 1983, and his research will be outlined in detail in next year's report

1. **Robust and diagnostic transformation methods** (with David Ruppert)

    The ordinary Box-Cox transformation methods (1964, J. Roy. Statist. Soc., Ser. B) are known to be quite useful but also extremely sensitive to the effects of unusual design or response points. Carroll (1980, J. Roy. Statist. Soc., Ser. B and 1982, Appl. Statist.) developed methods for well-designed experiments which overcome the effects of outliers on transformation methods. In instances where the predictor or factor space has not been well-designed, as in an observational study, outliers in the response can interact with the unusual design points to cause Carroll's method to break down. In this paper we develop two new methods for transformation which are not sensitive to the interaction of design and response. By means of a series of examples we indicate that our methods work well in practice.

2. **Correcting for measurement error in logistic regression** (with L.A. Stefanski)

    Logistic regression is a generalized linear model in which the outcome is

dichotomous, e.g., success or failure. In many instances where logistic regression is used, the predictor variables are measured with substantial error, which has a negative effect on the usual maximum likelihood method which ignores the measurement error. The purpose of this paper is to develop a usable theory and new methods which can account for measurement error. We consider a local measurement error theory for logistic regression which is applied to four different methods: ordinary logistic regression without accounting for measurement error, the functional maximum likelihood estimate, an estimate based on linearizing the logistic function and an estimator conditioned on certain appropriate sufficient statistics. Our asymptotic theory includes a bias-variance trade off, which we use to construct new estimators with better asymptotic properties.

3. Power transformations when fitting theoretical models to data (with David Ruppert)

This paper was listed in last year's report, but through this year we have improved and expanded the work by means of many additional examples. Here is a description of the paper.

We investigate power transformation in nonlinear regression problems when there is a physical model for the response but little understanding of the underlying structure. In such circumstances and unlike the ordinary power transformation model, both the response and the model must be transformed simultaneously and in the same way. We show by an asymptotic theory and a small Monte Carlo study that for estimating the model parameters there is little cost for not knowing the correct transform a priori: this is in dramatic contrast to the results for the usual case that only the response is transformed. Examples are included: in particular, we consider in detail the spawner-recruit relationship for Atlantic menhaden, as well as examples from chemical engineering.

4. <u>A note on estimating the binomial N</u> (with F. Lombard)

We consider the problem of estimating the size of a population in an area when the information available consists only of independent counts. The following biological example is typical, but other applications also exist. If we wanted to count the size of a population of rare animals, such as wolves, different observers in airplanes would fly over an area and obtain physical counts. Naturally, each observer will fail to count all the wolves, so in effect we see observation from a binomial population shose size is N and whose rate of sighting is p; we know neither N nor p. This paper discusses usable and stable methods for the estimation of N.

5. <u>Influence and diagnostics in logistic regression</u> (with L.A. Stefanski)

This is based on part of Stefanski's Ph.D. dissertation. Logistic regression is concerned with modeling the relationship between an explanatory vector x and a response variable y indicating the occurrence ($y = 1$) or nonoccurrence ($y = 0$) of some event. The statistical model postulates that

$$Pr(y = 1|x) = F(x^T\theta)$$

where $F(\cdot)$ is the logistic distribution function, $F(t) = 1/(1 + \exp(-t))$, and θ is an unknown parameter to be estimated from data (y_i, x_i) $i = 1, \ldots, N$. Models of this type are very popular and have applications in both the physical and social sciences. The usual method of estimation, maximum likelihood, operates under the assumption that the data is generated in strict accordance with model assumptions. Of course this is often not the case. In this research we study the estimation problem when certain model assumptions are violated.

Characteristic of real data are outlying responses and extreme design points either of which can have a deleterious effect on the quality of estimates obtained by maximizing the likelihood. Certain robust estimates are

proposed, based in part on a generalization to nonlinear regression of the modern theory of bounded influence estimation. Asymptotic theory is used to stucy the large sample performance of these methods, whose small sample performance is investigated through a series of examples.

6. Bounded influence estimation in heteroscedastic linear models (with D.M. Giltinan)

This is a summary of Mr. Giltinan's Ph.D. dissertation. Further work will be needed in 1984 to write papers from this work, to be submitted for publication. Heteroscedastic linear models arise quite frequently in such areas as chemical kinetics, radioimmunoassay and in various problems in econometrics. The problem of estimation in such models is considered, where the variance is modelled as a (known) function of the mean (or subset of the explanatory variables) and an unknown variance parameter. If a reasonable estimate of the variance parameter is obtained, weighted inference based on the estimated variances is preferable to unweighted regression.

Normal-theory maximum likelihood estimates of the variance parameter are highly susceptible to outliers in the data--the influence curve (IC) for the MLE is unbounded. We consider 3 classes of estimates which bound the influence, analogous to the bounded-influence regression estimates considered by Krasker, Mallows, and Krasker and Welsch. Within each class we obtain estimates of the variance parameter which are efficient subject to a bound on the influence. The estimates which we obtain are also useful to the data analyst in providing diagnostic information about unusual or highly influential data points.

Since the IC is an asymptotic tool, some effort should be made to evaluate the performance of the estimates in small samples. We wrote Fortran

programs to compute the estimators described above and used the estimators in the analysis of a number of data sets arising in practice. By and large the estimators behave as the large-sample theory leads us to expect, providing stable inference and useful diagnostic information about the data.

7. <u>A stochastic population model for managing the Atlantic menhaden fishery and assessing managerial risks</u> (with D. Ruppert, R.L. Reish, R.B. Deriso)

A management-oriented population model for Atlantic menhaden is presented. The model includes an age-structure, a stochastic egg-recruitment relationship, density-dependent juvenile growth, age-dependent fishing mortality, and fecundity dependent upon size as well as age. The model was used to investigate three types of harvesting strategies: constant yearly catch policies, constant fishing mortality rate policies, and "egg escapement" policies which are defined in the paper. Because of stochastic recruitment, constant yearly catch policies appear unsuitable for managing Atlantic menhaden. Both other types of policies are suitable, but the "egg escapement" policies have higher long-term average catches. Using decision theory we investigated risks due to the randomness of recruitment and to the estimation errors for the biological parameters in our model. The risks appear to be acceptable.

8. <u>On the maximum likelihood estimate for logistic errors-in-variables regression models</u>

Maximum likelihood estimates for errors-in-variables models are not always root-N consistent. We provide an example of this for logistic regression.

References

1. R.J. Carroll and D. Ruppert, Robust and diagnostic transformation methods, Inst. of Statistics Mimeo Series, in preparation.

2. R.J. Carroll and L.A. Stefanski, Correcting for measurement error in logistic regression, Inst. of Statistics Mimeo Series No. 1542, October 1983.

3. R.J. Carroll and D. Ruppert, Power transformations when fitting theoretical models to data, Inst. of Statistics Mimeo Series No. 1383, January 1982, to appear in JASA.

4. R.J. Carroll and F. Lombard, A note on estimating the binomial N, Inst. of Statistics Mimeo Series No. 1539, September 1983.

5. L. Stefanski and R.J. Carroll, Influence and diagnostics in logistic regression

6. D. Giltinan and R.J. Carroll, Bounded influence estimation in heteroscedastic linear models

7. D. Ruppert, R.L. Reish, R.B. Deriso and R.J. Carroll, A stochastic population model for managing the Atlantic menhaden fishery and assessing managerial risks, Inst. of Statistics Mimeo Series No. 1532, June 1983.

8. R.J. Carroll, On the maximum likelihood estimate for logistic errors-in-variables regression models, Inst. of Statistics Mimeo Series No. 1528, April 1983.

WOLFGANG HÄRDLE
(now at the University of Frankfurt)

Dr. Wolfgang Härdle of the University of Heidelberg visited Chapel Hill during the spring semester of 1983 and conducted research in nonparametric density and regression function estimation. Dr. Härdle's research reports are listed below.

1. On jackknifing kernel regression function estimators [1]

Estimation of the value of a regression function at a point of continuity using a kernel-type estimator is discussed and improvements of the technique by a generalized jackknife estimator are presented. It is shown that the generalized jackknife technique produces estimators with faster bias rates. In a small example it is investigated if the generalized jackknife method works for all choices of bandwidths. It turns out that an improper choice of this parameter may inflate the mean square error of the generalized jackknife estimator.

2. Approximations to the mean integrated squared error with applications to optimal bandwidth selection for nonparametric regression function estimators [2]

Discrete versions of the Mean Integrated Squared Error (MISE) provide stochastic measures of accuracy to compare different estimators of regression functions. These measures of accuracy have been used in Monte Carlo trials and have been employed for the optimal bandwidth selection for kernel regression function estimators, as shown in Härdle and Marron (1983). In the present paper it is shown that these stochastic measures of accuracy converge to a weighted version of the MISE of kernel regression function estimators, extending a result of Hall (1982) and Marron (1983) to regression function estimation.

3. <u>The nonexistence of moments of some kernel regression estimators</u> (with J.S. Marron)

In the setting of nonparametric density estimation, it is seen that the moments of kernel based estimators (with high order kernels) may not exist. Thus the popular error criterion of mean square error may be useless in this setting.

4. <u>Random approximation to an error criterion of nonparametric statistics</u> (with J.S. Marron)

This paper deals with a quite general nonparametric statistical curve estimation problem. Special cases include estimation of probability density functions, regression functions, and hazard functions. The class of "fractional delta sequence estimators" is defined and treated here. This class includes the familiar kernel, orthogonal series and histogram methods. It is seen that, under some mild assumptions, both the Average Square Error and the Integrated Square Error provide reasonable (random) approximations to the Mean Integrated Square Error. This is important for two reasons. First, it provides theoretical backing to a practice that has been employed in several empirical studies. Second, it provides a vital tool for use in selecting smoothing parameters for several different nonparametric curve estimators by cross-validation.

References

1. W. Härdle, On jackknifing kernel regression function estimators, Inst. of Statistics Mimeo Series No. 1526, May 1983.

2. W. Härdle, Approximations to the mean integrated squared error with applications to optimal bandwidth selection for nonparametric regression function estimators, Inst. of Statistics Mimeo Series No. 1529, May 1983.

3. W. Härdle and J.S. Marron, The nonexistence of moments of some kernel regression estimators, Inst. of Statistics Mimeo Series No. 1537, August 1983.

4. Marron, J.S. and W. Härdle, Random approximations to an error criterion of nonparametric statistics, Inst. of Statistics Mimeo Series No. 1538, September 1983.

PUBLICATIONS

J. Berger and R. Wolpert, Estimating the mean function of a Gaussian process and the Stein effect, J. Multivariate Anal., 13, 1983, 401-424.

S. Cambanis and E. Masry, Sampling designs for the detection of signals in noise, IEEE Trans. Information Theory, IT-29, 1983, 83-104.

S. Cambanis, R. Keener and G. Simons, On α-symmetric multivariate distributions, J. Multivariate Anal., 13, 1983, 213-233.

S. Cambanis, Complex symmetric variables and processes, in Contributions to Statistics: Essays in Honour of Norman L. Johnson, P.K. Sen, Ed., North Holland, New York, 1983, 63-79.

S. Cambanis and N.L. Gerr, A simple class of asymptotically optimal quantizers, IEEE Trans. Information Theory, IT-29, 1983, 664-676.

R.J. Carroll, Two examples of transformations when there are possible outliers, Appl. Statist., 31, 1982, 149-152.

R.J. Carroll and D. Ruppert, A comparison between maximum likelihood and generalized least squares in a heteroscedastic linear model, J. Amer. Statist. Assoc., 77, 1982, 878-882.

R.J. Carroll, Adapting for heteroscedasticity in linear models, Ann. Statist., 10, 1982, 1224-1233.

R.J. Carroll, Power transformations when the choice of power is restricted to a finite set, J. Amer. Statist. Assoc., 77, 1982, 980-915.

R. J. Carroll and D. Ruppert, Some aspects of estimation in heteroscedastic regression models, in Statistical Decision and Theory and Related Topics, Vol. 3, S.S. Gupta and J.O. Berger, Eds., Academic Press, 1982, 231-242.

R.J. Carroll and D. Ruppert, Weak convergence of bounded influence regression estimates with applications to repeated significance tests in clinical trials, J. Statist. Plann. Inf., 7, 1982, 117-129.

R.J. Carroll, Tests for regression parameters in power transformation models, Scand. J. Statist., 9, 1983, 217-222.

R.J. Carroll, Discussion of Huber's paper "Minimax aspects of bounded influence regression," J. Amer. Statist. Assoc., 78, 1983, 78-79.

R.J. Carroll, R.N. Holt, and V. Scarpello, Towards understanding the contents of the "Black Box" for predicting complex decision making outcomes, Decision Sci., 14, 1984, 253-269.

R.J. Carroll and D. Ruppert, Robust estimation in random ciefficient regression models, in Contributions to Statistics: Essays in Honour of Norman L. Johnson, P.K. Sen, Ed., North Holland, 1983, 81-96.

G. Kallianpur and V. Mandrekar, Nondeterministic random fields and Wold and Halmos decompositions for commuting isometries, in Prediction Theory and Harmonic Analysis, A. Pesi Masani Folume, V. Mandrekar and H. Salehi, Eds., North Holland, 1983, 165-190.

G. Kallianpur and D. Ramachandran, On the splicing of measures, Ann. Probability, 11, 1983, 819-822.

G. Kallianpur and V. Mandrekar, Commuting semigroups of isometries and Karhunen representation of second order stationary random fields, in Theory and Application of Random Fields, G. Kallianpur, Ed., Lecture Notes in Control and Information Sciences, No. 49, Springer, 1983, 126-145.

G. Kallianpur and R.L. Karandikar, A finitely additive white noise approach to nonlinear filtering, J. Appl. Math. Opt., 10, 1983, 159-185.

G. Kallianpur, On the diffusion approximation to a discontinuous model for a single neuron, in Essays in Honour of Norman L. Johnson, P.K. Sen, Ed., North Holland, 1983, 247-258.

M.R. Leadbetter, G. Lindgren and H. Rootzén, Extremes and Related Properties of Random Sequences and Processes, Springer Statistics Series, 1983.

M.R. Leadbetter and D. Wold, On estimation of point process intensities, in Contributions to Statistics: Essays in Honour of Norman L. Johnson, P.K. Sen, Ed., North Holland, 1983, 299-312.

J. Milliken, M.R. Leadbetter and R.J. Carroll, Hazard indicators for polycyclic organic matter, Proc. 1982 P.O.M. Conf., Battelle, Columbus, Ohio, 1983.

J.O. Oberpriller, V.J. Ferrans, and R.J. Carroll, Changes in DNA content, number of nuclei and cellular dimensions of young rat atrial myocytes in response to left coronary artery ligation, J. Molec. Cell. Card., 15, 1983, 31-42.

T. de Oliveira, Bivariate extremes: Models and statistical decision, published in Conference Proceedings (precise information currently unavailable), 1983.

H. Rootzén, Central limit theory for martingales via random changes of time, in Probability and Mathematical Statistics, Essays in Honour of Carl-Gustav Esseen, A. Gut, Ed., Uppsala University, 1983,

ACCEPTED FOR PUBLICATION (AFTER NOV. 1, 1983)

R.D. Abbott and R.J. Carroll, Interpreting multiple logistic regression coefficients in prospective observational studies, Amer. J. Epidem., 1984, to appear.

R.J. Carroll and D. Ruppert, Discussion of Hinkley and Runger's paper "The Analysis of Transformed Data," J. Amer. Statist. Assoc., 1984, to appear.

R.J. Carroll and D. Ruppert, Power transformations when fitting theoretical models to data, J. Amer. Statist. Assoc., 1984, to appear.

R.J. Carroll, C. Spiegelman and R.D. Abbott, On errors-in-variables for binary regression models, Biometrika, 1984, to appear.

G. Kallianpur and C. Bromley, Generalized Feynman integrals using analytic continuation in several complex variables, Stochastic Analysis, M. Pinsky, Ed., Marcel-Dekker, 1984.

G. Kallianpur and R.L. Karandikar, Some recent developments in nonlinear filtering theory, Acta Applicandae Mathematicae, 1, 1984, 249-284.

G. Kallianpur and R.L. Karandikar, The nonlinear filtering problem for the unbounded case, Stochastic Proc. Appl., 14, 1984, to appear.

G. Kallianpur and R.L. Karandikar, A finitely additive white noise approach to nonlinear filtering: A survey, Proc. 6th Int. Symp. on Multivariate Anal., 1984, to appear.

G. Kallianpur and H.H. Kuo, Regularity property of Donsker's delta function, Proc. 1983 CBMS-NSF Regional Conf. on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications, 1984, to appear.

G. Kallianpur and R. Wolpert, Infinite dimensional stochastic differential equation models for spatially distributed neurons, Proc. 1983 CBMS-NSF Regional Conf. on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications, 1984, to appear.

M.R. Leadbetter, Extremes and local dependence in stationary sequences, Z. Wahrsch. verw. Geb., 1984, to appear.

M.R. Leadbetter, Extremes in dependent random sequences, Statistical Extremes and Applications, Proc. NATO-ASI, J. T. de Oliveira, Ed., Reidel, 1984, to appear.

E. Masry and S. Cambanis, Spectral density estimation for stationary stable processes, Stochastic Proc. Appl., 1984, to appear.

W. McCormick, A conditional limit law result for jumps in the sequence of partial maxima of a stationary Gaussian process, Sankhyā, Ser. A, 45, 1983, 191-200.

W. McCormick, An iterated logarithm result for extreme values from Gaussian sequences, J. Appl. Probability, 1984, to appear.

D. Ruppert, R.L. Reish, R.L. Deriso and R.J. Carroll, Monte-Carlo optimization by stochastic approximation, with application to harvesting of Atlantic menhaden, Biometrics, 1984, to appear.

D. Ruppert, R.L. Reish, R.B. Deriso and R.J. Carroll, A stochastic model for managing the Atlantic menhaden fisher and assessing managerial risks, Can. J. Fish., 1984, to appear.

H. Rootzén, Extremes in continuous stochastic processes, Statistical Extremes and Applications, Proc. NATO-ASI, J.T. de Oliveira, Ed., Reidel, 1984, to appear.

Z. Suchanecki and A. Weron, Decomposability of cylindrical martingales and absolutely summing operators, Math. Z., 1984, to appear.

CENTER FOR STOCHASTIC PROCESSES

TECHNICAL REPORTS

22. "Exact analysis of a delayed delta modulator and an adaptive differential pulse-code modulator." N.L. Gerr, Nov. 82.

23. "Nonparametric spectral density estimation for stationary stable processes." E. Masry and S. Cambanis, Dec. 82. Stochastic Proc. Appl., Appl., 1984, to appear.

24. "Measure-valued equations for the optimum filter in finitely additive nonlinear filtering theory." G. Kallianpur and R.L. Karandikar, Jan. 83.

25. "On limiting distributions of order statistics with variable ranks from stationary sequences." Shihong Cheng, Jan. 83.

26. "Limit laws for the maximum of weighted and shifted i.i.d. random variables." D. Daley and P. Hall, Feb. 83. Ann. Probability, 12, 1984, to appear.

27. "On a problem concerning spacing." Shihong Cheng, Feb. 83.

28. "Central limit theory for martingales via random change of time." H. Rootzen, Feb. 83. Probability and Mathematical Statistics, Essays in Honour of Carl-Gustav Esseen, A. Gut, ed., Uppsala University, 1983, 154-190.

29. "An iterated logarithm law result for extreme values from Gaussian sequences." William P. McCormick, March 83. J. Appl. Probability, 1984, to appear.

30. "Weak and strong law results for a function of the spacings." William P. McCormick, May 83.

31. "Infinite dimensional stochastic differential equation models for spatially distributed neurons." G. Kallianpur and R. Wolpert, May 83. Proc. 1983 CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional spaces and Their Applications, to appear.

32. "Harmonizable stable processes on groups: Spectral, ergodic and interpolation properties." A. Weron, June 83.

33. "The nonlinear filtering problem for the unbounded case." G. Kallianpur and R.L. Karandikar, June 83. Stochastic Proc. Appl., 1984, to appear.

34. "Extremes in dependent random sequences." M.R. Leadbetter, June 83. Statistical Extremes and Applications, Proc. NATO-ASI, T. de Oliveira, ed., Reidel, 1984, to appear.

35. "On the central limit theorem in Hilbert space." V.V. Sazonov and B.A. Zalesskii, June 83. Proc. 6th Int. Symp. on Multivariate Anal., to appear.

36. "Extreme value theory for moving average processes." H. Rootzen, July 83.

37. "A general principle for limit theorems in finitely additive probability: The dependent case." R.L. Karandikar, July 83.

38. "Some recent developments in nonlinear filtering theory." G. Kallianpur and R.L. Karandikar, July 83. Acta Appl. Math., 1, 1984, 249-284.

39. "Positive definite symmetric functions on finite dimensinal spaces, I: Applications of the Radon transform." D. St. P. Richards, Aug. 83.

40. "Recent developments in probabilistic geotechnical engineering." A.M. Hasofer, Aug. 83.

41. "Convergence of quadratic forms in p-stable random variables and θ_p-Radonifying operators." S. Cambanis, J. Rosinski, and W. Woyczynski, Oct. 83.

42. "A finitely additive white noise approach to nonlinear filtering: A brief survey." G. Kallianpur and R.L. Karandikar, Nov. 83. Proc. 6th Int. Symp. on Multivariate Anal., to appear.

43. "A certain class of diffusion processes associated with nonlinear parabolic equations." T. Funaki, Nov. 83.

44. "The Markov property of the filter in the finitely additive white noise approach to nonlinear filtering." G. Kallianpur and R.L. Karandikar, Nov. 83.

45. "A linear filtering problem using Radon transform." S. Takanaka, Oct. 83.

46. "Maximum likelihood estimation in the multiplicative intensity model." A. Karr, Nov. 83.

47. "Some doubly stochastic time series models." D. Tjostheim, Nov. 83.

48. "Consistency in least squares estimation: A Bayesian approach." H. Rootzen and J. Sternby, Nov. 83.

49. "Weak convergence of semimartingales." M. Metivier, Nov. 83.

50. "On smoothed probability density estimation for stationary sequences." J. Castellana and M.R. Leadbetter, Dec. 83.

51. "Regularity property of Donsker's delta function." G. Kallianpur and H.H. Kuo, Dec. 83. Proc. 1983 CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications, to appear.

52. "The diffusion approximation of the spatially homogeneous Boltzmann equation." T. Funaki, Dec. 83.

IN PREPARATION

S. Cambanis, C.D. Hardin and A. Weron, Ergodic properties of stationary stable processes.

S. Cambanis, C.D. Hardin and A. Weron, Decompositions of stable processes of the Wold, Hida and Karhunen-Loève type.

S. Cambanis, Preservation of stability by a random linear operator.

C.D. Hardin, General (asymmetric) stable variables and processes.

T. Hsing, J. Hüsler and M.R. Leadbetter, Compound Poisson limit theorems for high level exceedances by stationary sequences.

T. Hsing, Point processes associated with extremes of stochastic sequences.

G. Kallianpur, R.L. Karandikar and D. Kannan, Analytic and sequential Feynman integrals on abstract Wiener and Hilbert spaces and a Cameron-Martin formula.

D. Tjøstheim, Estimation in doubly stochastic time series models.

G. Kallianpur and R. Wolpert, Nonlinear diffusion approximations in problems of neuronal activity.

MANUSCRIPTS SUBMITTED FOR PUBLICATION

N.L. Gerr and S. Cambanis, Analysis of a delta modulator.

N.L. Gerr and S. Cambanis, Analysis of adaptive differential PCM of a stationary Gauss-Markov input.

INSTITUTE OF STATISTICS MIMEO SERIES TECHNICAL REPORTS

1526. On jackknifing kernel regression function estimators, W. Härdle, May 1983.

1528. On the maximum likelihood estimate for logistic errors-in-variables regression models, R.J. Carroll, April 1983.

1529. Approximations to the mean integrated squared error with applications to optimal bandwidth selection for nonparametric regression function estimators, W. Härdle, May 1983.

1532. A stochastic population model for managing the Atlantic menhaden fishery and assessing managerial risks, D. Ruppert, R.L. Reish, R.B. Deriso and R.J. Carroll, June 1983.

1537. The nonexistence of moments of some kernel regression estimators, W. Härdle and J.S. Marron, August 1983.

1538. Random approximations to an error criterion of nonparametric statistics, J.S. Marron and W. Härdle, September 1983.

1539. A note on estimating the binomial N, R.J. Carroll and F. Lombard, September 1983.

1542. Correcting for measurement error in logistic regression, R.J. Carroll and L.A. Stefanski, October 1983.

IN PREPARATION

Influence and diagnostics in logistic regression, L. Stefanski and R.J. Carroll.

Bounded influence estimation in heteroscedastic linear models, D. Giltinan and R.J. Carroll.

Robust and diagnostic transformation methods, R.J. Carroll and D. Ruppert.

STOCHASTIC PROCESSES SEMINARS

Nov. 3	p-stable measures on Banach spaces, 4 lectures.
Nov. 4	A. Weron
Nov. 17	Wroclaw Technical University and
Dec. 1	University of North Carolina.

Nov. 29   Smoothness priors in time series, Will Gersch, University of Hawaii and Bureau of the Census.

Dec. 8   Estimation of the mean frequency of the EMG-signal, J. de Maré, Chalmers Unive-sity of Technology, Sweden.

Jan. 12   Regressions in stable systems, C.D. Hardin, University of Wisconsin-Milwaukee and University of North Carolina.

Jan. 19   Sojourns and extremes of stationary processes, S. Berman, Courant Institute of Mathematical Sciences.

Jan. 26   Multiple Wiener integrals, S. Kakutani, Yale University.

Feb. 9   Maximum likelihood estimation in the multiplicative intensity model for counting processes, Martin Jacobsen, Copenhagen University.

Feb. 14   Robust filtering, G. Kallianpur, University of North Carolina.

Feb. 16	Nonlinear filtering theory, 3 lectures
Feb. 23	R.L. Karandikar
Mar. 3	Indian Statistical Insititue and University of North Carolina.

Mar. 2   On series representations for linear predictors, Peter Bloomfield, Princeton University and University of North Carolina.

Mar. 30   Can you feel the shape of a manifold through Brownian motion? Mark Pinsky, Northwestern University.

April 5   A survey of results on optimal quantization of a random variable, J. Kieffer, University of Missouri-Rolla.

April 6   Stochastic control and stochastic mechanics, W. Fleming, Brown University.

April 7   Stochastic control and nonlinear filtering, W. Fleming, Brown University.

April 13	On the central limit theorem in Hilbert space, 2 lectures
April 21	V.V. Sazonov, Steklov Mathematical Institute, Moscow.

April 27   Radon transforms and α-symmetric multivariate distributions, D. Richards, University of North Carolina.

May 4   A linear filtering problem using the Radon transform, S. Takenaka, Nagoya University and the University of North Carolina.

May 11   Path integrals and stochastic processes in physics, Cécile DeWitt, University of Texas.

June 22	Inference about functional parameters for a Brownian bridge with applications, M. Akritas, University of Rochester.
July 5	Conjugate distributions and variance reduction in ruin probability simulations, S. Asmussen, University of Copenhagen.
July 7 July 20 July 21 Aug. 1 Aug. 11 Aug. 17	Weak convergence of semimartingales, 6 lectures M. Métivier Ecole Polytechnique, Paris and University of North Carolina.
July 27 July 28 Aug. 3	Stochastic approximation, 3 lectures M. Métivier Ecole Polytechnique, Paris and University of North Carolina.
Aug. 23	Stochastic differential equations involving a fluctuation of exponential type, T. Hida, Nagoya University and University of North Carolina.
Aug. 24	Objective probability for unique objects, A.M. Hasofer, University of New South Wales and University of North Carolina.
Aug. 25	Central limit theory for martingales, H. Rootzén, University of Copenhagen and University of North Carolina.
Oct. 14	Detection in a non-Gaussian environment, S. Schwartz, Princeton University.
Oct. 19	Some doubly stochastic time series models, D. Tjøstheim, University of Bergen and University of North Carolina.
Oct. 26	Asymptotic estimates of lower tail probabilities of sums of nonnegative random variables, N. Jain, University of Minnesota.
Oct. 31	Inference for point processes: An introduction, A. Karr, Johns Hopkins University and University of North Carolina.

LIST OF PROFESSIONAL PERSONNEL ASSOCIATED WITH THE RESEARCH REPORT

1. Faculty Investigators: S. Cambanis
R.J. Carroll
G. Kallianpur
M.R. Leadbetter

2. Visitors   Senior: N. Dinculeanu (July 83)
A.M. Hasofer (Aug. 83)
D. Kannan (Nov. 82-May 83)
A.F. Karr (Sept. 83-present)
M. Métivier (June-July 83)
H. Rootzén (Jan. 83-present)
A. Weron (Nov. 82-June 83)
W. Woyczynski (June 83)

    Junior: J. de Maré (Nov. 82)
T. Funaki (Aug. 83-present)
C. Hardin (Nov. 82-May 83)
W. Härdle (Jan.-May 83)
M. Jacobsen (Jan. 83)
R.L. Karandikar (Nov. 82-present)
W.P. McCormick (Nov. 82- May 83)
S. Takenaka (Nov. 82-May 83)
D. Tjøstheim (Aug. 83-present)
R. Wolpert (Nov. 82-May 83)

3. Graduate Students: S. Christensen
N.L. Gerr
D. Giltinan
L. Hazareesingh
T. Hsing
H. Hucke
M. Marquez
V. Perez-Abreu
L. Stefanski

INTERACTIONS

S. Cambanis gave a colloquium at the Case Western Reserve Probability Consortium (Dec. 82), five lectures at the Workshop in Statistics in Crete, Greece (Dec. 82), and talks at the Conference on Stochastic Processes and Their Applications at Cornell (July 83) and the International Symposium on Information Theory at St. Jovite , Quebec (Sept. 83). He also organized an invited session on dependence structure in stochastic processes at the annual meeting of the Institute of Mathematical Statistics in Toronto (Aug. 83).

R.J. Carroll presented invited seminars on Box-Cox transformations at the University of Pennsylvania (Feb. 83) and at the IMS-ASA-ENAR regional meeting in Nashville (Mar. 83),and on measurement error in binary regression at Southern Methodist University (Mar. 83), at the National Institute of Environmental Health Sciences (June 83), and at the IMS-ASA-ENAR annual meeting in Toronto (Aug. 83). He organized an invited session on data analysis at the IMS-ASA-ENAR meeting in Nashville (Mar. 83).

G. Kallianpur gave colloquium talks at Louisiana State University (Dec. 82), University of Łodz, Poland (Aug. 83), University of California, Los Angeles (Jan. 83), University of British Columbia (Apr. 83), the Layman Lectures (two) at the University of Nebraska (Nov. 82), and invited lectures at the CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications at Baton Rouge (May 83), the 6th International Symposium on Multivariate Analysis in Pittsburgh (July 83), and the IFIP Conference on System Modeling, Filtering and Control at the Technical University of Lyngby, Denmark (July 83).

M.R. Leadbetter presented invited talks at the annual meeting of the Institute of Mathematical Statistics in Toronto (Aug. 83), the NATO ASI meeting on Extreme Value Theory and Applications in Vimeiro, Portugal (Sept. 83) and at the University of Copenhagen, Denmark. His book with G. Lindgren and H. Rootzén on extremes was published by Springer-Verlag in this period.

C.D. Hardin gave a talk at the Conference on Stochastic Processes and Their Applications at Cornell (July 83).

M. Jacobsen gave a colloquium at the University of Virginia.

D. Kannan gave colloquia at the Universities of Waterloo (Mar. 83) and Georgia (Apr. 83) and attended the CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications at Baton Rouge (May 83).

R.L. Karandikar gave colloquia at Northwestern University (Jan. 83) and the University of Illinois (Jan. 83) and a talk at the Conference on Stochastic Processes and Their Applications at Cornell (July 83). He also attended the CBMS-NSF Regional Conference on Stochastic Differential Equations in Infinite Dimensions and Their Applications at Baton Rouge (May 83).

M. Métivier gave a talk at the Conference on Stochastic Processes and Their Applications at Cornell (July 83).

H. Rootzén gave invited talks at the annual meeting of the Institute of Mathematical Statistics in Toronto (Aug. 83) and the NATO ASI meeting on Extreme Value Theory and Applications in Vimeiro, Portugal (Sept. 83), and a colloquium at the Case Western Reserve Probability Consortium at Kent State University (Nov. 83). He also organized an invited session on dependent central limit theory at the 44th session of the International Statistical Meeting in Madrid (Sept. 83).

L. Stefanski gave a talk at the annual IMS-ASA-ENAR meeting in Toronto (Aug. 83).

S. Takenaka gave a colloquium at the University of Kentucky (Jan. 83).

A. Weron gave a colloquium at the Georgia Institute of Technology (Feb. 83), and talks at the Conference on Stochastic Processes and Their Applications at Cornell (July 83) and the International Symposium on Multivariate Analysis in Pittsburgh (July 83).

R. Wolpert attended the CBMS-NSF REgional Conference on Stochastic Differential Equations in Infinite Dimensional Spaces and Their Applications at Baton Rouge (May 83), the Kiefer-Wolfowitz Memorial Conference at Cornell (July 83) and the Conference on Stochastic Processes and Their Applications at Cornell (July 83).

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