MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

Tagungsbericht 51/1986

Statistik stochastischer Prozesse

23. 11. bis 29. 11. 1986

An der Tagung "Statistik stochastischer Prozesse", die unter der Leitung von W. Fieger (Karlsruhe) und N. Keiding (Kopenhagen) in Oberwolfach stattfand, nahmen 44 Stochastiker teil (davon eine Teilnehmerin aus Kanada, vier Teilnehmer aus den USA, zwei aus Dänemark, zwei aus Frankreich und je einer aus China, der CSSR, Finnland, Japan, den Niederlanden und der Schweiz). Neben einigen allgemeineren Themen aus der mathematischen Statistik und aus der Kontrolltheorie wurden in den Vorträgen vor allem die Themenbereiche

- Punktprozesse und Sprungprozesse
- Erneuerungsprozesse
- Markoff-Prozesse
- Likelihoodprozesse
- ARMA-Prozesse
- Zeitreihen

behandelt. Die Tagung war für alle Teilnehmer sehr anregend. Überraschenderweise haben sehr viele Teilnehmer aus der Bundesrepublik Vortragsbeiträge zu der hier bisher nicht so stark vertretenen "Statistik stochastischer Prozesse" beigesteuert; dadurch haben sich erfreulich viele neue Kontakte zwischen ausländischen und deutschen Teilnehmern angebahnt.

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Vortragsauszüge

H.Z. An

The asymptotic behavior of nonstationary ARMA processes

Consider a nonstationary ARMA process x(t), i.e. x(t) satisfies the following autoregressive moving average model

$$x(t)-a_1x(t-1)-a_2x(t-2)-\ldots-a_px(t-p)=\varepsilon(t)-b_1\varepsilon(t-1)-b_2\varepsilon(t-2)-\ldots-b_q\varepsilon(t-q)$$

where $\varepsilon(t)$'s are i.i.d. series with zero mean and variance σ^2, the roots of the characteristic polynomial, $A(u)=u^p-a_1u^{p-1}-a_1u^{p-2}-\ldots-a_{p-1}u-a_p$, of autoregressive part in ARMA model mentioned above, lie on and inside the unit circle. Let d be the largest multiplicity of all the distinct roots on the unit circle of A(u). We have proved the following results:

$$\limsup_{n\to\infty} \sum_{t=1}^{n} x^2(t)\cdot(n^{2d}\log\log n)^{-1} < \infty \quad \text{a.s.}$$

$$\lim_{n\to\infty} \sum_{t=1}^{n} x^2(t)\cdot n^{\delta-2d} = \infty \quad \text{a.s. for any } \delta > 0$$

$$\lim_{n\to\infty} (\log n)^{-1} \sum_{t=1}^{n} x^2(t)\cdot t^{-2d} = c \quad \text{a.s.}$$

where c is a positive number.

E.Arjas

Some martingale ideas related to goodness-of fit in survival analysis

The martingale-based defintition of hazard has many concrete implications in the statistical modeling of survival data. One such, which is of particular interest when one is considering diagnostic graphical methods, is the "no trend"-property of martingale sample paths. As an example of this we study the well-known Cox's regression model for survival data. We propose a diagnostic graphical method for detecting incorrectly specified models. The method is easy to use; it

does not require the estimation of alternative models, and it only employs quantities already appearing in the partial likelihood expression which is needed in the parameter estimation. By applying the martingale CLT, one gets an idea of the randomness contained in the graphs when the model is well specified.

H. Benzing

Dynamic programming solutions for optimal design problems in stochastic processes

We consider a stochastic process with unknown trend. For the estimation of the unknown trend parameter, only a finite number k of time instants and only one realization of the process are available.
First, for a fixed tuple $(t_1,\dots,t_k)$ of time instants, this problem is formulated as a linear model and the method of generalized -least squares leads to a BLUE. As a consequence the BLUE and the variance of the BLUE depend on $(t_1,\dots,t_k)$.
We then proceed to determine an optimal design; i.e. a tuple $(t_1,\dots,t_k)$ which minimizes the variance in the set of all BLUEs.
Our main result is to show how to compute optimal designs using a dynamic programming approach.

H. Cremers

Weak convergence of stochastic processes with paths in general function spaces with an application to quantile processes (joint work with D. Kadelka).

A general concept proving weak convergence of stochastic processes in certain Lusin (in particular polish) path spaces (e.g. C,D,Lp,Lip-spaces) is derived. A special corollary is the following statement:

Theorem. Let $\{\xi_n : n \in \mathbb{N}_0\}$ be a sequence of stochastic processes with paths in $\mathcal{L}p^E(\nu)$, E Banach space. Then $\xi_n \Rightarrow \xi_0$ provided that:
(a) the finite dimensional distributions converge weakly,
(b) $\limsup_{n\to\infty} \int |\xi_n|^p d\,\mathbb{P} \otimes \nu \leq \int |\xi_0|^p d\,\mathbb{P} \otimes \nu$.

(b) is a certain weak tightness condition. This result will be applied

to weak convergence of quantile processes. It is shown that (under certain conditions) the weighted empirical quantile process

$$r_n^w(w,u) := \begin{cases} \sqrt{n}\, w(u)(Q_n(w,u)-Q(u)), & \frac{1}{n+1} < u < \frac{n}{n+1} \\ 0, & \text{elsewhere} \end{cases}$$

converges weakly in $L_2(0,1)$ to $w \cdot g \cdot B$, where $g(u) := 1/f(Q(w))$, f=density quantile function, and B= Brownian bridge on [0,1].

R. Dahlhaus

Approximate Gaussian likelihood estimation for stationary processes

Let $x_{t,\theta}$, $t \in Z$ be a stationary Gaussian process which depends on a vector of unknown parameters θ. We study the exact maximum likelihood estimate for θ and approximations to it. Since the asymptotic efficiency of the estimates is not a sufficient criterion to judge the quality of the estimates we develop a more refined criterion. By using this criterion we explain the behaviour of the above estimates.

F. Eicker

Time series diagnostics - empirical trend-seasonal decomposition in an exploratory situation.

Considered are time series data $x_1,\ldots,x_M$ whose data generating mechanism is unknown (e.g. many economic time series), and hypothetical model assumptions are avoided. The data suggest an approximate description by a smooth trend plus (or times) a seasonal curve. The many existing methods (e.g. SABL, X11, BAYSEA, SCHLICHT) for achieving this are extended by a weighted SCHLICHT (JASA 1981)-type procedure, supplemented by diagnostic graphical checks. This restricted or penalized least squares procedure minimizes a WHITTACKER-HENDERSON functional which is quadratic in the 2M parameters of the trend $t_1,\ldots,t_M$ and of the seasonal $s_1,\ldots,s_M$. Therefore the solution of the minimum problem is obtained from a system of linear equations (analogous to the normal equations). Its coefficient matrix is shown to be non-singular. Its adjustment parameters are chosen after visual checks. Some

properties of the solution are discussed. (For details comp. Proc. Sympos. Operations Research Munich, August 1985, Physica Verlag).

B.K. Ghosh

A modification of Edgeworth expansions.

Suppose we are given a sequence $\{T_n\}$ of random variables with $P(T_n \leq t)=F_n(t)$, $E(T_n)=\mu_n$, Var $(T_n)=\sigma_n^2$ for $n \geq 1$. It is often possible to write

$$F_n(t)=\Phi(x)+n^{-1/2}(a_0+a_1x^2)\varphi(x)+o(n^{-1/2}) \qquad (1)$$

or $$F_n(t)=\Phi(x)+n^{-1/2}(a_0+a_1x^2)\varphi(x)+n^{-1}(b_0x+b_1x^3-\frac{1}{2}a_1^2x^5)+o(n^{-1}), \qquad (2)$$

where a_i, b_i are constants, $x=(t-\mu_n)/\sigma_n$, and $\Phi(x)$ and $\varphi(x)$ are, respectively, distribution function and density function of a standard normal variable. There are numerous examples in central limit theorems and statistical estimation and hypothesis testing problems where (1) or (2) holds uniformly under a given set of conditions. In this paper, we prepare modifications of (1) and (2), under the same set of conditions, which are easier to compute and generally more accurate than (1) and (2), especially in the tail regions.

R.D. Gill

Left truncation and Markov processes.

Starting with a paper by Woodroofe (1985;Ann. Statist.) the model of left truncation has received a lot of attention. In this model, one observes n i.i.d. copies of two positive r.v.'s X and U conditional on U < X. Here, U and X are an independent entry and failure time respectively. Both have unknown distributions: that of X is to be estimated non parametrically, while that of U is a nuisance parameter. In the literature the NPMLE of F_X has been constructed and its asymptotic normality and efficiency has been proved, but by heavy and non-transparent calculations. Here we show that the left truncation model is essentially equivalent to a three-state Markov process model for which the parallel results are both well-known and easy to obtain. By the equivalence, all the results transfer immediately to the left-truncation model.

P.E. Greenwood

Fixed accuracy and minimaxity

Lai and Siegmund (Ann.Stat. 85) study a linear autoregressive scheme and show that a sequential estimator has the property that the normed error is asymptotically normal uniformly over a parameter range [-1,1]. A similar result was obtained by Liptser and Shiryayev (Statistics of Stochastic Processes 71) in continuous time for a class of diffusions. In this report we show that the second result is, asymptotically, a version of the first and we show an asymptotic minimax property of the Lai and Siegmund estimator which comes from the same calculation.

X. Guyon

Statistics for Markov fields on a lattice

Soit $X = \{X_i,\ i \in L\}$ une champ sur l'ensemble dénombrable infini de sites L. Soit, en chaque site $i \in L$, $f_i(x_i, y_i; \theta)$ une (pseudo)-densité conditionelle de $(x_i|\cdot)$. Soit alors la pseudo vraisemblance:

$$F_n(\theta) = \sum_{C_n} \log f_i(x_i, y_i, \theta)\ (y_i = (x_j)_{j \neq i}) \text{ et } \hat{\theta}_n \in \operatorname{Arg\,Max}_{\Theta} F_n(\theta)$$

On étudie sous quelles conditions suffisantes simple sur

$$\{X, (f_i)_{i \in L}, (C_n)_{n \in \mathbb{N}}\},$$

$\hat{\theta}_n$ a des bonnes propriétés asymptotiques. Si X est un champ markovien, la méthode est celle décrite par Besog [74].
Deux contextes pour X sont examinés; le premier utilise explicitement une hypothèse de faible dépendance sur le champ X. On donne alors, pour une situation générale mais aussi la situation markovienne, des conditions suffisante de consistence, normalité asymptotique, et test de (pseudo) rapport de vraisemblance. Le deuxième est celui de champs de Gibbs a espace d'état fini: pour les estimateurs de codage, les resultats subsistent en situation stationnaire.

K. Helmes

An analogue of the Hartman-Wintner law (of the iterated logarithm) for the first Heisenberg Group.

Let (X_i,Y_i) be a sequence of i.i.d. random variables in $\mathbb{R}^2$ where $E[X_1]=E[Y_1]=0$, $E[X_1Y_1]=0$ and $E[X_1^2]=E[Y_1^2]=1/2$. Assume that the $\mu:=$ Law$((X_1,Y_1))$ can be embedded into 2-dim. Brownian Motion (W_t), i.e. $\exists\tau$, $E[\tau]=I$ such that $\mu \sim W(\tau)$. Put $S_k = \sum_{i=1}^{k} X_i, R_k = \sum_{i=1}^{k} Y_i$ and

$$H_n = \sum_{k=1}^{n} (S_{n-1}Y_k - R_{n-1}X_k).$$

We shall show that

$$\limsup_{n\to\infty} \frac{H_n}{\frac{2}{\pi}\cdot n\cdot \log\log n} = 1 \qquad \text{a.e.}$$

This theorem complements the analogous result derived by Crepel & Reynette (ZW, 1977), using different techniques, under the condition that $\exists\delta>0$ such that $E[X_1^{2+\delta}]$, $E[y_1^{2+\delta}]<\infty$.

R. Höpfner

Asymptotic optimal inference for continuous-time Markov chains.

We deal with asymptotic optimal inference in a time-continuous ergodic Markov chain with countable state space, based on observation of the process up to time t. Let the infinitesimal generator depend on an unknown parameter. Under weak assumptions on the parametrization, using a variant of Hajek's convolution theorem due to Droste-Wefelmeyer (1984), limit distributions as $t \to \infty$ of sequences of competing estimators for the unknown parameter are more spread out than a specified normal distribution. We prove this by means of point processes and related martingales.

J. Jacod

Convergence for likelihood ratio processes.

Consider a sequence $(P^n, P'^n)_{n\geq 1}$ of paires of probability measures on filtered spaces $(\Omega^n, F^n, (F_t'^n)_{t\geq 0})$ and the (generalized) likelihood process $(Z_t^n)_{t\geq 0}$ of P'^n with respect to P^n. As the "limiting" process for Z^n we consider $Z_t = \exp(W_t - \frac{t}{2})$, where W is a standard Brownian motion. Then we give a sufficient condition for the convergence $Z_t^n \xrightarrow{\mathcal{L}(P^n)} Z_t$. More interestingly the same conditions, valid for all $t \geq 0$, are indeed necessary and sufficient for having the functional weak convergence $Z_t^n \xrightarrow{\mathcal{L}(P^n)} Z_t$. The conditions are expressed in the terms of the Hellinger process, and other auxiliary processes satisfying a kind of "Lindeberg condition". Finally we also give some sufficient (not necessary) conditions for having the same results when Z is of the form $Z_t = \exp X_t$ and X is a process with independent increments.

A.F. Karr

Estimation intensity functions of Poisson processes via the method of sieves, with application to positron emission tomography.

Let N be a Poisson point process on $\mathbb{R}^d$, $d \geq 1$, with unknown intensity function λ satisfying $\int \lambda(x)dx = 1$. Given as data i.i.d. copies $N_1, \ldots, N_n$, the log-likelihood function (with constant terms omitted) $L_n(\lambda) = \sum_{i=1}^{n} \int (\log \lambda) dN_i$ is unbounded above. Using the method of sieves of Grenander, the parameter space is restricted in such a manner that maximum likelihood estimators exist. Computation of these estimators is performed using a function space version of the EM algorithm. Strong consistency of the restricted maximum likelihood estimators, with respect to the norm on $L^1(\mathbb{R}^d)$, is established given appropriate rate of decrease of sieve widths. An application to positron emission tomography - an important form of medical imaging - is considered in some detail.

M. Kolonko

A general bandit model with infinitely many arms.

Bandit models combine sequential optimization and some sort of sequential estimation. The aim is to find a sequential design of experiments that maximizes the reward in a finite sequence of trials. The particular structure of the bandit model allows to reduce the effort to solve the underlying dynamic programming problem. This was extensively studied for the case of finitely many (in particular two) actions ("arms"). In the present paper the relevant structural properties such as (generalized) monotonicity and convexity are shown to hold for infinitely many actions as well.

J.-P. Kreiss

Testing linear hypothesis in ARMA-models.

We consider stationary solutions $\{X_t : t \in \mathbb{Z} = \{0, \pm 1, \pm 2, \ldots\}\}$ of the following stochastic difference equation

$$X_t = \mu + \sum_{i=1}^{p} q_i X_{t-i} + e_t + \sum_{j=1}^{q} b_j e_{t-j}, \quad t \in \mathbb{Z},$$

where the random variables $(e_t; t \in \mathbb{Z})$ form a sequence of independent and identically distributed observations, with zero mean, finite variance, and an absolute continuous density f of their distribution (error-distribution). For the parameter

$$\theta = (\mu, a_1, \ldots, a_p, b_1, \ldots, b_q) \in \Theta \subset \mathbb{R}^{p+q+1}, \ \Theta \text{ open},$$

we construct asymptotically maximin tests for hypothesis of the following form: $H_0 : b_{s+1} = \ldots = b_q = 0$ $(0 < s < q)$. To reach this we use local asymptotic normality of the considered model. Since these tests depend on the unknown error-distribution, we discuss alternative proposals, for example a score-test using rank-residuals. From this we are able to construct adaptive tests, i.e., tests which are asymptotically optimal and do not depend on the error-distribution.

H. Künsch

Nonstationary autoregressions on $\mathbb{Z}^2$.

We extend the model class of stationary autoregressions on $\mathbb{Z}^2$ to situations where the data X_i, $i \in \mathbb{Z}^2$, have a ranging level and possibly also a ranging gradient. In contrast to the time series case the approach of modeling a certain difference of the X_i as stationary autoregression fails. We use instead so-called intrinsic models from geostatistics and define nonstationary autoregressions to be intrinsic models with spectrum const.$\cdot P(\omega)^{-1}$ where $P(\omega)$ is a trigonometric polynomial $1 - \Sigma\, \alpha_k \cos(k\omega)$ which has a zero at $\omega=0$. $\Sigma\, \alpha_k X_{i-k}$ is then the best linear predictor of X_i given X_j, $j \neq i$, which reproduces polynomials of low order. The unknown parameters of the model are estimated by maximizing a Whittle type approximation to the Gaussian log likelihood.

H.L. Lerche

An optimal property of the repeated significance test.

The motivating question for this lecture was the following: Which is the natural counterpart to Wald's sequential probability ratio test for testing composite hypotheses without an indifference zone which has similar optimality properties as Wald's test? It turned out that the repeated significance test is this procedure, both in a frequentistic and in a Bayes sense. It stops sampling at the first n, at which $|S_n|/\sqrt{n} \geq a > 0$ and decides. Here S_n denotes the sum of n independent identically distributed observations with unknown mean and known variance.

H. Luschgy

Minimax property of Pitman estimators in a Banach space.

The problem of estimation of the shift of an infinite dimensional probability measure or, what is the same, global estimation of the mean function of a stochastic process will be considered. Conditions for the existence and the minimax character of Pitman estimators (= minimum risk equivariant estimators) are given.

P. Mandl

Self-optimizing controls for processes with unknown parameters

Systems defined by linear stochastic differential equations are studied. The design method for feedback controls is assumed chosen (e.g. pole-shifting). Unknown parameters are estimated by the least squares method, and the actual control selected in accordance with the certainty equivalence principle.

An invariance principle for quadratic functionals is presented, and its use to classify self-tuning controls is explained.

U. Müller-Funk

Differentiating randomly stopped probability ratios

Linearization of randomly stopped probability ratios is at the bottom of any local approach to problems in sequential analysis and we consider some technical aspects of that matter. Attention is restricted to i.i.d. observations, $\mathcal{L}(X_j)\in\mathcal{F}=\{F_\theta,\theta\in\Theta\subset\mathbb{R}^d\}$. Put $L_n(\theta)=\prod_1^n(dF_\theta/dF_0)(X_j)$, $0\in\mathrm{int}(\Theta)$. Basic assumptions: (A) $F_\theta\approx F_{\theta'}$ $\forall\theta,\theta'\in\Theta$, ($B_p$) $p(L_1^{1/p}(\theta)-1)$ is weakly differentiable with derivative $L_1\in\mathbf{L}_p(p=1,2)$, (C) The Kullbach-Leibler numbers $K(0,\theta)$ behave like $\theta^2 J$, where J denotes the Fisher-information. Now, let $(N,(T_n)_{n\geq 1})$ be a "sequential statistic" such that $P_\theta(N<\infty)=1$ around 0 and $E_0(N)<\infty$. Then, $T_N p(L_N^{1/p}-1)$ is weakly differentiable with derivative $T_N L_N$, $L_N=\Sigma_1^n L_1(X_j)$, without further restrictions in case $p=1$ and under the condition $\lim_{\theta\to 0} E_0(\|T_N\|^2)<\infty$ in case $p=2$. (This result extends earlier findings by Abraham(1969)). As an application, we present a streamlined version of Wolfewitz's sequential Cramer-Rao-bound.

G. Neuhaus

On a class of goodness of fit tests

In a series of papers Behnen and Neuhaus developed a theory of linear rank statistics with estimated score functions in order to enlarge the sensitivity of linear rank tests to larger areas of alternatives.

It is shown that the same ideas apply in a natural way to goodness of fit testing problems for parametric classes of distributions. The resulting test statistics are quadratic forms in the observations with a new class of kernels stemming from density estimation. Asymptotic results are given and relations to other test statistics are discussed.

Y. Ogata

Statistical models for earthquake occurrences and residual analysis for point processes.

This paper reviews and discusses a class of stochastic models which have been proposed for the origin times and magnitudes of earthquakes occuring in a geophysical region. The models are compared for a homogeneous Japanese data set for the years 1885-1980, using the likelihood method. Using the best fitted model, a time change of scale is made to investigate the deviation of the data from the model. Conventional graphical methods to test the stationary Poisson process are then useful for such a purpose; we may call this residual analysis for point processes. Effective use of the residual analysis makes it possible to find characteristic features of the data set which were not included in the modelling. By means of the above procedures we join the controversy over the usefulness of seismic quiescence for the prediction of a major earthquake.

G. Pflug

Efficiency and adaptivity in nonergodic models

We consider the model

$$X_{i+1}=\rho X_i+\varepsilon_i, \quad X_0=0$$

where ε_i are i.i.d. distributed with density ψ. If $|\rho|>1$ the model is nonergodic. We derive the limit of the log-likelihood process and show that the ML-estimate for ρ is not efficient in this case. Moreover, an adaptive estimate for ρ is constructed, with ψ being the nuisance. It is not necessary that ψ is symmetric or even that it has zero mean.

D. Plachky

MVU estimators for the expectation of permutable functions

Let $\mathcal{P}$ denote the family of all probability distributions P such that a given sequence $(X_k)_{k\in\mathbb{N}}$ of real valued random variables are exchangeable relative to P. It is shown that $P\to E_p(f\circ X), f:\mathbb{R}^\infty\to\mathbb{R}$ permutable and measurable, $f\circ X\in L_2(P)$, $P\in\mathcal{P}$, $X=(X_1,X_2,\ldots)$, is estimable by a MVU estimator based on the first n random variables $X_1,\ldots,X_n$ ($n\in\mathbb{N}$ fixed) if and only if there exists a function $g:\mathbb{R}^n\to\mathbb{R}$, permutable and measurable, such that $g\circ(X_1,\ldots,X_n)=f\circ X$ P-a.e. for all $P\in\mathcal{P}$ holds. Furthermore, the consistency of the MVU estimator for $P\to E_p(h\circ(X_1,\ldots,X_n))$ with $h:\mathbb{R}^n\to\mathbb{R}$, $h\circ(X_1,\ldots,X_n)\in L_2(P)$, $P\in\mathcal{P}$, is discussed. In particular, the MVU estmator for $P\to E_p(X_1), P\in\mathcal{P}$, based on $X_1,\ldots,X_n$, is consistent with respect to $P\in\mathcal{P}$ for $\{0,1\}$-valued random variables X_k, $k\in\mathbb{N}$, if and only if the corresponding sequence $(X_k)_{k\in\mathbb{N}}$ is i.i.d. relative to P.

H. Pruscha

On the problem of fitting a parametric trend component in continuous-time jump-type processes

We consider stochastic processes with continuous time parameter and discrete state space possessing an intensity process within the framework of multivariate point processes. The paper concentrates on the problem of defining and estimating a trend-component in such processes. We assume that the intensity process depends on a parameter β, the maximum likelihood (m.l.) estimator $\hat{\beta}$ of which enjoying the usual asymptotic properties. Now a trend is defined in this paper by a factor multiplied to the intensity which may depend on a parameter α. We present two different types of trend functions (polynomial and reciprocal functions) under which the asymptotic properties of $\hat{\beta}$ are inherited by the m.l. estimator $(\hat{\alpha},\hat{\beta})$ of the joint parameter (α,β). These trend functions, in particular, can be consistently estimated. The techniques of our analysis are partly taken from the martingale approach to point processes (see Lipster & Shiryayev, 1978) and are

partly guided by path-constructional methods in the canonical space (see Jacobsen, 1982).
Examples where the presented theory applies are Markov processes of the jump-type, Markov branching processes with immigration and linear OM-(or learning-) processes. A numerical example with earthquake data serves as an illustration.

L. Rüschendorf

Testing the marginals of time series

Let $X_1,\ldots,X_n$ be a time series, where under the hypothesis and alternative the sequence of marginals are fixed but no assumptions are made concerning the kind of dependence structure. A motivation for a model of this type is the possible different structure of the sample spaces (so e.g. X_1 might be a continuous time stochastic process, X_2 a random set, X_3 real etc.) so that the classical descriptions of dependence like regression, correlation or association do not apply.
For the model given above it is possible to determine the level α maximum tests as well as minimax- and weighted minimax tests explicitely. In a modified model with restriction on the possible dependence, it is still possible to calculate robustness properties of general tests but the problem of determination of least favourable pairs is still open.

M. Schäl

On estimation and control

The paper is concerned with a discrete time system $X_{t+1}=F(X_t,U_t,V_t)$ influenced by a control U_t and disturbed by a random noise V_t. The distribution of V_t may not only depend on X_t and U_t, but also on an unknown parameter α. In spite of this, we desire to design a control law which will result in adequate behaviour of the system measured by a given cost criterion.
To each α an optimal stationary control $U_t=\varphi(X_t,\alpha)$ is associated. At each time, α is estimated by a MLE $\hat{\alpha}_t$. Then a control scheme is

considered which at time t chooses with high probability the control $\varphi(X_t,\hat{\alpha}_t)$ and with small probability some controls which yield further information about α. Thus both the consistency of $(\hat{\alpha}_t)$ is guaranteed and the cost criterion is minimized asymptotically.

N. Schmitz

Remark on minimax sequential tests for the drift of a Wiener process

A Wiener process with unknown drift μ is observed continuously and one has to decide between

(1) $H_1:\mu\leq\mu_0$, $H_2:\mu>\mu_0$ (w.l.o.g. $\mu_0=0$).

It is assumed that the loss function is of the form

(2) $W(\mu,d_i)=s|\mu|^r 1_{H_{3-i}}(\mu)$

and that the costs of observing the process are linear. The problem is to determine a minimax test. For this completely symmetrical problem the class of symm. SPRT's is of special interest: Generalizing a result of DeGroot (AMS '60) we have for $0\leq r\leq r_0$ (≈ 3.691) determined a symm. SPRT which is minimax in the class of all sequential tests. But for $r>r_0$ there does i.g. not exist any symm. SPRT which is minimax for (1) under this loss function (2). This is proved by determining a minimax test under all symm. SPRT's and by giving a "triangular" test which has a lower minimax risk.

E. V. Slud

Partial-likelihood analysis of stochastic-process regression models with time-dependent covariates.

An abstract definition of Partial Likelihood (stemming from Cox 1975) will be given in a form suitable for (semi-)parametric inference on stochastic processes. A generalization applicable to continuous-time pure-jump processes, regarded as marked point-processes, will be introduced, and aspects of the Maximum Partial Likelihood Estimation theory for such processes (generalizing results of Wong 1986) will be sketched. Two further mathematical issues will be raised: first, the relationship between "calculability" of compensators and the existence of

continuous-time partial likelihood for classes of continuous-path processes.

M. Sørensen

Sequential methods for exponential families of stochastic processes

A particular type of one-parameter exponential families of stochastic processes is studied. Many widely used models for stochastic processes are of this type. In particular, sampling rules for which the models are non-curved exponential families, exactly or approximately, are considered. Specifically, observation is stopped when a linear combination of the canonical statistics reaches a pre-assigned level. The distribution of the exactly or approximately minimal sufficient statistic is found in terms of its Laplace transform, and this result is used to prove consistency and asymptotic normality of the maximum likelihood estimator. Also Bartlett adjustments are considered. The general results are applied to processes of the diffusion type and to counting processes. Finally, extensions of the results to multidimensional parameters are considered and applied to finite state Markov processes.

J. Steinebach

On the optimality of strong approximation rates for compound renewal processes

The optimality of certain approximation rates appearing in strong invariance principles for partial sums indexed by a renewal process is discussed. The results extend and unify earlier work on the best rates in the invariance principles for renewal counting processes (cf. Csörgö, Horváth, St. (1987), Ann. Probab. (to appear)). The motivation for the present discussion comes from a recent approximation of stopped sums due to Csorgö, Deheuvels and Horváth (1987), Adv. Appl. Probab. (to appear), which can be stated here under somewhat weaker assumptions, thus allowing for a specific dependency structure between the summands and the stopping renewal process.

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