MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

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Statistische Modelle und Entscheidungen

14.12. bis 20.12.1980

This meeting was organised by Professor Dr. Viktor Kurotschka and Professor Dr. Walter Vogel to provide an opportunity for senior and younger scientists from different Statistical Schools to discuss the different approaches and different aspects of statistical inference as they are in progress now. This meeting was initiated in the hope that the excellent facilities and the corresponding good atmosphere of the Mathematical Research Institute would stimulate a discussion on "the state and the directions of statistical research activities" which would be beyond the arguments known from the professional literature and would provide better communication on the subject than the usual big professional meetings can.
In a number of longer survey talks followed by enganged discussions (continued after dinner) and a number of talks on specific research programms the participants stressed these points from their individual point of view. But as the meeting proceeded and in particular during the concluding discussion on Friday afternoon chaired by Professor Dr. Willem van Zwet more and more issues emerged on which common appreciation and agreement has been reached.

This meeting proved once more the stimulating and extremely communicative athmosphere of the Oberwolfach Institute, a statement made indipendendly by numerous participants of this meeting, expressing the hope of a possibility to continue the discussion on these subjects in near future.

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Vortragsauszüge

ANDERSSON, S. On the structure of multivariate statistical analysis

The invariant or geometric formulation of the ordinary one-dimensional regression analysis reduces the problem of the complete solution of the likelihood inference to the algebraic problem of finding projections on and dimensions of subspaces. When it comes to problems involving the covariance a similar technique does not exist.

The theory presented in the talk includes a definition of a class of hypotheses in the normal distributions, which contains all well-behaved normal models and still allows to work out the complete solution of the likelihood inference. This class of models is defined by means of group-invariance. The naive but very usefull advantage of a general theory for statistical models is of course that one is able to resolve and complete "old examples" and create new examples "ad libitum". The perception of the models, which is created by the general theory in the invariant formulation, is a more important and deeper advantage. This allows us to learn how to transform and combine models. For example one can construct and solve complicated models from simple models.

BARNDORFF-NIELSEN, O. Exponential Transformation Models

The class of exponential transformation models, i.e. transformation models which are also exponential families, is investigated. It is shown, using standard exponential family theory, that the group of transformations on the sample space generating the model induces affine transformation groups on the parameter space and on the range space of the minimal sufficient statistic, the induced groups being in fact representations of the original transformation group. The model function may be rather explicitly expressed in terms of these representations and it possesses a number of important particular properties. The possibility of extending exponential transformation models to larger (composite) exponential transformation models is considered, such extensions serving, for instance, the purpose of model control. The inference for (composite) exponential transformation models is described in general terms and a number of examples of such models is discussed. The paper starts with an introduction to transformation models and a unified treatment of their distribution theory, required in the subsequent discussion of the exponential transformation models.

BECKER, G. Sampling plans for a family of counting processes

The following problem is considered: given a pure birth process and sampling at times $0 = t_o < t_1 < \dots < t_n = T$ with n,T given in advance, how does one have to choose t_i to get good estimators for the birth rate λ.

Properties of "good" schemes which minimize the loss of information are investigated, especially the case n = 2.

It is shown how the results generalize for a wider class of processes introduced by Aalen, where the intensity of a counting process can be written as $\theta Y(t)$ with θ unknown and Y observable process.

BERNARDO, J.M. Information Measures in Bayesian Statistics

The role of information measures in Bayesian Statistics is described. Statistical Inference is held to be a particular decision problem in which the utility function is a logarithmic measure of information. This provides a general framework in which important applications to statistics of information theorical ideas may be studied. In particular, (i) maximization of the expected information is shown to be a particular instance of maximizing the expected utility; (ii) Shannon's measure of expected information is used to define reference posterior distributions; and (iii) an axiomatic argument is provided to use Kullback's directed divergence as a general measure for goodness of fit.

BOCK, H.H. Testing two alternatives with intermediate stages

The usual tests for a hypothesis H_o (density f_o) against an alternative H_1 (density f_1) have been generalized by Rüger (Metrika 27, 1980) by introducing 2k + 1 stages or actions ($H_o \triangleq$) $A_{-k},\dots,A_{-1},A_o, A_1,\dots,A_k (\triangleq H_1)$: where the decision for "A_i" should support the belief in H_1 (resp. H_o) the more the greater (the less) the number i is ($A_o \triangleq$ "undecided"). This has been formalized by requiring that a corresponding decision procedure $\varphi = (\varphi_{-k},\dots,\varphi_o,\dots,\varphi_{+k})$ should have probabilities $\beta_i = E_1\varphi_i(X)$, $\alpha_i = E_o\varphi_i(X)$ with a high "discriminating power":

$\beta_i/\alpha_i \geq a_i, \alpha_{-i}/\beta_{-i} \geq b_i$ (i = 1,...,k; with two given decreasing sequences $a_k > \ldots > a_1 > 1$, $b_k > \ldots > b_1 > 1$). We consider this problem in the framework of decision theory and seek the decision procedure which minimizes the Bayesian risk under these side conditions. By analysing the dual problem and using some geometrical considerations we find: 1) For k = 1 (3 stages) the constrained solution can be obtained (in principle) by cutting off the acceptance regions of the usual Bayesian procedure (if necessary at all). 2) For k = 2 (5 stages) the situation is different because there are situations (even with monotone losses) where in the constrained solution the acceptance region for $A_2 (\hat{=} H_1)$ is composed of two disjoint intervals (for $\lambda = f_1/f_0$) separated by the acceptance region for A_1. Insofar these side conditions lead to somewhat artificial results.

CALIŃSKI, T. <u>The basic contrasts of an experimental design with special reference to the optimality criteria</u>

A general definition of basic contrasts of an experimental block design is given. With this concept the three common optimality criteria (G-, D- and A-optimality) are redefined in a more general sense. Accordingly, also other notions, such as balance and orthogonality of block designs, are treated within this generalized approach. It is shown that G-optimality is attained only by orthogonal block designs considered in the usual sense, while D-optimality and A-optimality may be attained by balanced designs, or in unrestricted classes by orthogonal designs, considered within the generalized framework. Thus only in a special case the three criteria coincide.

The main advantage of the present approach is that the various concepts of defining properties of a design can be considered within one unified theory.

FRASER, D.A.S. <u>Qualities and requirements in models and inference</u>

The recognition of various qualities in model components and inference methods provides insight concerning statistical inference. The view is taken that statistical inference involves determining what is <u>implied by</u> the model and the data, perhaps with additives. The distinctions among "theories of inference" then rest on the additives, rather than on a notion that special ways of thinking will produce something beyond that implied by the model and data. Some relevant qualities, arbitrary, descriptive, exhaustive categorical versus frequency, notational, necessary, are discussed.

GAFFKE, N. Exact D-optimal designs for regression models

For the usual regression model

$$EY_x = y(x) = \Sigma_{i=1}^{k} a_i f_i(x) \quad , \quad x \in X \quad ,$$

under the usual assumptions on X and the f_i, the problem is to determine an exact (D-optimal) design $d^* = (x_1,\dots,x_n) \in X^n$ with n observations, which maximizes det M_d over $d \in X^n$, where $M_d = \frac{1}{n} (\Sigma_{\nu=1}^{n} f_i(x_\nu) f_j(x_\nu))_{i,j=1,\dots,k}$ = Information matrix (per observation).

This problem is studied under the assumption that there exists an approximate D-optimal design ε^* with exactly k support points $x_1^*,\dots,x_k^*$. A sufficient condition is given for D-optimality of an exact design having the same support as ε^* and giving almost equal frequencies to the points x_i^*. As applications polynomial regression on an interval and linear and quadratic multivariate regression on a simplexare considered.

GHURYE, S.G. Discrete Approximations to Continuous Models - Estimating the Loss of Information

In many problems, the random variables are continuous-valued, but all actual realizations are discrete. Statistical theory deals with optimal decisions for the theoretical family, J, of continuous distributions, whereas the actual problem concerns the family, J_D, of discrete approximations to the members of J.

The talk will give a brief survey of the existing literature on the problem of loss of information due to grouping of data, and will present some new results in terms of Kullback-Leibler information.

GYÖRFI, L. Recent results on nonparametric regression estimate and multiple classification

Let (X,Y) be a random vector taking values in $R^d \times R$. The problem is to estimate the regression function

$$m(z) \triangleq \mathbb{E}(Y/X = z) \qquad z \in R^d$$

based on independent copies (X_1,Y_1) ... (X_n,Y_n) of (X,Y). The concept of weak and strong universal consistency of regression estimates is introduced, and some results on kernel and nearest neighbor estimates are reviewed.

The consequences of universal consistency of regression estimates are shown for the universal consistency of multiple classification rules.

HUBER, P.J. Models for bounded influence regression

Bounded influence regression has been proposed in various forms by serveral authors (Hampel, Mallows, Krasker and Welsch) as a device to cut down the potentially dangerous influence of observations sitting at influential points. We examine it critically from the point of view of finite sample minimax theory. The following conclusions are reached: (1) Bounded influence regression appears to be both too pessimistic - since it safeguards against Nature selectively putting the gross errors on the most influential points - and not pessimistic enough, since it disregards dangers caused by slight biases in non-influential observations. (2) Its recommendation is however sound with regard to cutting down the influence of really high leverage points (i.e. where the diagonal element of the hat matrix $H = X(X^TX)^{-1}X^T$ exceeds 0.5).

JOHANSEN, S. Curvature of statistical models

I intend to give a survey of the recent literature on the application of curvature in inference.

Curvature has appeared useful in analysing the following problems.

1. Approximation to distribution of teststatistics and confidence intervals.
2. Discussion of bias and variance of maximum likelihood estimators.
3. Choice of parameter transformation.

Problem 1 has been treated by Beale (1960) who defined a measure of curvature of the solution locus in a non-linear regression problem. Box (1971) discussed the bias and showed how it could be evaluated by the removable curvature. Efron (1975) discussed second order efficiency and the choice of parameter transformation was taken up by Hongaard (1980). The general framework of differential geometry and its application to Efron's work is given by Th. Marlon (1978) and Amari (1980).

KREMER, E. — Bahadur efficiency at infinity of two-sample rank tests

For deriving results on Bahadur efficiency of two sample linear rank tests at alternatives far away from the hypothesis, the concept of Bahadur efficiency at infinity is introduced. A general formula for the value of this asymptotic efficiency is developped, showing the independence of the special sequence of alternatives, moving away from the hypothesis. For a reasonable test one at least should require that the test has high efficiency at alternatives far away from the hypothesis. This problem is treated by giving general conditions on the scores-generating function of a two-sample linear rank test under which the test is optimal (according to Bahadur efficiency) for each sequence of alternatives, moving away from the hypothesis. The theorems are applied to the Wilcoxon-, normal scores- and median test.

LIDLEY, D.V. — The inevitability of probability

Let the uncertainty of an event E, given an event F, be described by a real number x. Let the description be given a penalty score f(x,1) if E and F are both true; f(x,0) if E is false but F true; and zero if F is false. Then under assumptions of additivity of scores for different discriptions and admissibility of the scores it is shown that there exists a known function P(x) such that values of P(x) obey the rules of the probability calculus.

Since no such functions exist for descriptions which are significance levels, confidence levels or the possibilities of fuzzy logic, all these concepts are unsatisfactory and only probability (or a transform thereof, such as log-odds) is a sensible description of uncertainty. If $f_1(x,E)F$ and $f_2(x,E)F$ are two score functions, then $P_1(x_1) = P_2(x_2)$ where x_i is the description with f_i. If preferences between scores do not depend on the score functions then only a complete Bayesian description is satisfactory.

MAMMITZSCH, V. — An axiomatic approach to best estimates in linear models

Let $X = (X_1,\ldots,X_m)'$ random observations of unknown quantities $a = (a_1,\ldots,a_m)'$, X being distributed normal with mean value a. To characterize the "best" estimation $\hat{a}$ of the unknown a we postulate the following axioms:

Ax 1: If there is no functional connection between $a_1,\dots,a_n$, then $\hat{a} = X$.

Ax 2: If $(X_1,\dots,X_n)$ and $(X_{n+1},\dots,X_m)$ are independent with no functional connection between $(a_1,\dots,a_m)'$ and $(a_{n+1},\dots,a_m)'$, then $\widehat{(a_1,\dots,a_n)'}$ depends only on $(X_1,\dots,X_n)'$, $n < m$.

Ax 3: If ℓ is a linear mapping, $1 - 1$, then $\widehat{\ell(a)} = \ell(\hat{a})$.

As an example it is shown that in case $a_1 =\dots= a_m$; $X_1,\dots,X_m$ i.i.d. there holds $\hat{a}_1 = \overline{X}$, as is well known.

This axiomatic approach is essentially due to H. Richter.

NIEDERHAUSEN, H. <u>Exact Renyi-type distributions</u>

Starting with the Kolmogorov-Smirnov distributions, considerable efforts have been undertaken to find at least some exact distributions of Renyi-type. Instead of solving each of the related combinatorial problems seperately by ingenious but special ideas (like Andre's reflection principle) we use a general method for evaluating certain associated recursions under side conditions. This method has been derived from G.-C. Rota's Umbral Calculus. Originally designed only as a recipe for closed expressions of some of those recursions, it turned out to be even useful in improving the recursions themselves. Weighted Kolmogorov-Smirnov statistics, Kuiper- and Butler-statistics belong to the range of applications.

PUKELSHEIM, F. <u>A new optimality property of BIBDs</u>

Balanced incomplete block designs are known to be optimal for estimating treatment contrast in a normal model with additive treatment and block effects. Here we establish that BIBDs are optimal also for a maximal set of estimable parameters.

More precisely, competing designs must have support points which are contained in the support of the BIBD under investigation, and optimality is evaluated by generalized means of order $p \in [-\infty, +1]$ of the information matrix. The proof relies on a transition from exact to approximate block designs, and applies to the latter Kiefer-Wolfowitz type optimality characterizations.

REISS, R.D. — Asymptotic independence of distributions of normalized order statistics of the underlying probability measure

Let $Z_1 \leq \ldots \leq Z_n$ be the order statistics of a sample of size n. Let $1 \leq r_1 \leq \ldots \leq r_k \leq n$ and $\lambda_i = r_i/(n+1)$. If $r_{i+1} - r_i \geq 5$ for $i = 1,\ldots, k-1$, then it is proved that uniformly over all k-dimensional Borel sets B

$$|\underline{P}^n\{[f(F^{-1}(\lambda_i))(Z_{r_i} - F^{-1}(\lambda_i))]_{i=1}^k \in B\}$$
$$- Q^n\{(Z_{r_i} - \lambda_i)_{i=1}^k \in B\}| = O((\tfrac{k}{n})^{1/2}) \quad .$$

Q is the uniform distribution and $\underline{P}$ is a probability measure which has the distribution function F and the density $f = F^{(1)}$. Furthermore, it is assumed that $F^{(4)}$ exists and fulfills certain regularity conditions.

We conjecture that this result still holds true if the condition $r_{i+1} - r_i \geq 5$ is weakened to $r_{i+1} - r_i \geq 3$. It does not hold true if $r_{i+1} - r_i = 1$. In this case, a counterexample shows that for certain Borel sets B_n

$$\underline{\lim_n}|\underline{P}^n\{[f(F^{-1}(\lambda_i))(Z_{r_i} - F^{-1}(\lambda_i))]_{i=1}^{k(n)} \in B_n\}$$
$$- Q^n\{(Z_{r_i} - \lambda_i)_{i=1}^{k(n)} \in B_n\}| \geq 0$$

if $k(n)/n^{1/2} \to \infty$ as $n \to \infty$.

RUKHIN, A.L. — Universal Statistical

An estimator is said to be universal with respect to a class of loss functions if it is (generalized) Bayes procedure for each loss function from this class. The description of probability distributions and prior densities, which admit an universal estimator with respect to the class of all symmetric loss functions, is given. The geometrial structure of these universal estimators is obtained. We also discuss the relation of the universal estimation problem for general transformation parameter to functional equations of the D'Alembert's type.

SILVERMAN, B.W. Testing for multimodality

The problem of determining the number of modes in density underlying a given data set is important in many areas particularly in cluster analysis. Kernel probability density estimates can be used to obtain a statistic suitable for investigating multimodality: it is easy to prove a theorem which gives a computational method for finding this statistic. A "smoothed bootstrap" method is used to assess, in a natural way, the significance of the statistic obtained from the data. In contrast with most smoothing problems, there is no subjective choice of smoothing parameter, either in the calculation of the statistic or in the assessment of significance. A particular data set from chondrite meteors will be used to illustrate the technique.

It is hoped that this particular problem will go some way to illustrate the following points:

Some theoretical results can be used directly in practice. A technique may be attractive if it is computationally simple even if its precise mathematical properties are difficult to investigate.

There do exist smoothing problems where there is no arbitrary choice of smoothing parameter.

A simple nonparametric approach can often be used in cases where it is difficult even to formulate precise parametric models.

SMITH, A.F.M. Some Bayesian approaches to robustness and outliers

Some Bayesian approaches to modelling departures from standard assumptions (such as normality) will be presented and illustrated. In particular, we shall discuss the detection and accomodation of outliers and the problem of providing robust analyses of time series data. The latter has close connections with stochastic approximation ideas.

SPJÖTVOLL, E. Comparison of models

It is distinguished between model selection and model comparison. Most existing criteria for model evaluation are based upon measuring the overall fit of the various models. It is shown that in a certain sense the comparison of two models (or parameter values) is most efficiently done by calculating the significance probabilities of each model versus the others. The idea is extended to situations with an infinite number of parameters. If one has some way of estimating a "best" model, all other models may be evaluated by testing against the best model. For cases where the models may be parametrized with a single parameter one gets a curve describing the "acceptability" of the various values. One must, however, calculate the effect of the fact that the best model is selected in light of the data.

WALK, H. Optimization by stochastic approximation

There are treated, by stochastic approximation, problems of minimizing a regression function of several variables without and with constraints which in the latter case are given by regression functions, too. The functions need not be convex. - As to the first problem an argument of Kushner is modified and simplified by using summability theory. - In the case of constraints a primal-dual method is proposed which in its primal part consists of a sequence of inexact multi-step minimizations with stopping rules. Under regularity assumptions one obtains an a.s. approximation of the optimal value of the primal and the dual problem; under further regularity assumptions, especially uniqueness of a saddle-point, one obtains a.s. convergence to this point, the final degeneration of the procedure into a sequence of one-step subroutines and a functional central limit theorem.

WIERICH, W. Optimal designs for a special covariance model

We consider a special linear model of covariance analysis with one qualitative factor of influence (treatment), two quantitative factors of influence (covariates) which may vary in a compact interval, and linear regression functions. Under usual assumptions (no interaction between ANOVA- and regression part, uncorrelated observations with equal variances) the problem of characterizing exact optimal designs is discussed for a) the regression parameters b) the whole parameter vector when (i) the treatment marginals (ii) the total number of experiments is given. Because of the non-existence of uniformly optimal designs the analysis is based on the D-optimality criterion. It turns out that for given treatment marginals the covariates have - roughly spoken - to be equally distributed at the edge points. Besides a characterization of optimal covariates for special treatment marginals "good" covariates are given for general ones which allow the determination of optimal ("good") treatment marginals for the regression parameters (the whole parameter vector) for given total number of experiments.

WYNN, H.P. Random versus controlled experimentation

The debate about the contrast between controlled and "random" experiment touches many areas of inference. In the philosophy of science it is mentioned by Popper in the context of "micro" and "macro" experimentation. It underlies the old statistical arguments about randomization. In the social sciences there are questions about the validity of observational studies. The problem lies behind the understanding of some aspects of sequential statistical analysis. Related to this is the idea of dual control theory with "estimation" and "control" phases. In this talk we set out, with examples, a simple foundation for understanding the debate and suggest that a balance between the two kinds of experimentations is optimal.

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