Werk

Titel: Book Reviews

Jahr: 1998

PURL: https://resolver.sub.uni-goettingen.de/purl?358794056_0047|log9

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Book Reviews

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Thomas S. Ferguson: A Course in Large Sample Theory, Chapman & Hall, London, 1996, IX/245 pp., £24.99

Reviewed by E. Dettweiler, Tübingen

A university course on the asymptotic theory of statistical inference is a delicate task. The theory is based on advanced topics of probability theory such as central limit theory in function spaces, martingale theory, and stochastic integration. On the other hand, the students interested in such a course normally have previous knowledge only of basic probability theory and elementary statistics. The book by Ferguson shows a convincing way of teaching asymptotic methods given this restriction.

The book consists of four parts, each divided into several sections, where a central result is proved and then applied to nontrivial examples.

In the first part, the different notions of convergence of random vectors are introduced. This includes the laws of large numbers and the central limit theorem, as well as a discussion of the Berry–Esseen theorem and Edgeworth expansions.

The second part develops some basic tools of statistical asymptotic theory such as Slutsky's theorem and the theorem of Cramér. As a first application, the asymptotic distribution and power of the Pearson's chi-square test is derived.

Part 3 treats certain special topics by the methods developed before,

including the asymptotic behaviour of some time series statistics, some rank statistics, and the distributions of quantiles and extreme order statistics.

The last and most convincing part is entitled "efficient estimation and testing". First, a uniform strong law of large numbers due to LeCam is proved to get the strong consistency of maximum-likelihood estimates. Then the asymptotic normality of the maximum-likelihood estimate is shown. A thorough discussion of the Cramér-Rao lower bound and of the notion of asymptotic efficiency follows. The chapter ends with a treatment of the asymptotic normality of Bayes estimates, the likelihood ratio test statistic, and minimum chi-square estimates.

Ferguson's book is very carefully written and the number of pages (245) is agreeably limited. In all parts, the results are stated and proved in a multivariate setting. In every section, the theoretical part is followed by examples, which are of some relevance. The exercises at the end of every section contain additional examples, and it should be stressed that masterly solutions to these exercises are given in an appendix.

Altogether, this is a very suitable textbook and reference for courses which are not based on preceding lectures in more advanced probability theory.

Paul Malliavin with Hélène Airault, Leslie Kay, Gérard Letac: Integration and Probability, Graduate Texts in Mathematics, Springer-Verlag, 1995, XXI/322 pp., DM 74.00, öS 540.20, sFr 71.50

Gérard Letac: Integration and Probability by Paul Malliavin: Exercises and Solutions Exercises and Solutions Manual, Springer-Verlag, 1995, VIII/142 pp., DM 48.00, öS 374.40, sFr 48.00

Reviewed by H. Heyer, Tübingen

The present graduate text on "integration and probability" was preceded by a French edition published by Masson with the more specific title "intégration, analyse de Fourier, probabilités, analyse gaussienne". It appeared on the market along with an additional paperback containing problems and their solutions that were well-tuned to the exposition of the main book. The team of authors (and translators) led by the distinguished master intends to address first-year graduate students. There is an forthcoming book on "Stochastic Analysis" by P. Malliavin for graduate students in their second year.

Measure, integration, and probability form the topic of a category of text books which are sprouting up in abundance. By the canonization of the subject in favor of standardized teaching, these text books look very much alike, and it provides a genuine challenge to their authors to offer surprises in selecting material or in choosing approaches. Very fortunately, the book under review presents such innovative aspects, one of them being the discussion of Gaussian Sobolev spaces and a first treatment of the stochastic calcu-

lus of variations in Chap. V. In this chapter, the authors define Gaussian probability spaces, construct canonical bases of such spaces, and prove the Cameron–Martin theorem for the Gaussian sequence space. In the subsequent sections they discuss Gaussian Sobolev spaces by applying Hermite expansions, the martingale approximation of the space $L^p(\mathbb{R}^{\mathbb{N}})$ by spaces $L^p(\mathbb{R}^n)$, and finally the regularity (absolute continuity) of probability distributions. The idea of considering abstract probability spaces with a natural underlying differentiable structure leads to a stochastic calculus of variations.

How could this ambitious program be fulfilled in an introduction to integration and probability? Malliavin explains his concept in the Preface: He chose an axiomatic method of exposition. Chapter I is devoted to abstract measure theory, Chap. II to Radon measures. In Chap. III, vector differentiation and Sobolev spaces are introduced. Here first preparations are set up for the striking Chap. V. Further preparations on conditioning, independence, orthogonality, and a surprisingly economic treatment of basic martingale and differentiation theory follow in Chap. IV.

The reviewer can hardly try to praise the leading spirit of the present book more appropriately than Mark Pinsky did in his Foreword: "Professor Malliavin is uniquely qualified to introduce the student to analysis with the proper mix of abstract theories and concrete problems". In fact the inventor of the (Malliavin) stochastic calculus of variations has succeeded in leading beginners in probability to his very field of research, on a well-paved route and "without tears". A wonderful book, recommendable to anybody who really wants to take probability theory seriously.

Bandt, Christoph, Graf, Siegfried, Zähle, Martina: Fractal Geometry and Stochastics, Progress in Probability Vol. 37, Birkhäuser Verlag, Basel-Boston-Berlin, 1995, XI/245 pp., DM 118.--, öS 861.40, sFr 98.--

Reviewed by Hiroshi Sato, Fukuoka

In order to give an impression of the flavor of the book, we would like to select two papers and comment their central statements.

M. Denker: *Remarks on weak limit laws for fractal sets.*

The main theorem is the following:

Theorem 3. Let m be a Gibbs measure on the shift space Ω. Let $\beta \geq 0$ and $\alpha(n) \to 0$. For $\omega^* \in \Omega$ and a fixed sequence $B_n \in \mathcal{F}_{[n+\beta \log n] \cap [w_0^*, \ldots, \omega_{n-1}^*]}$, where $\mathcal{F}_k$ is the σ-field generated by all k-cylinders $[a_0, \ldots, a_{k-1}]$, define

$$F_n^x(t) = \sum_{j=1}^{\infty} \mathbf{I}_{\{m(B_n)\phi_j(x) \leq t + \alpha(n)\}},$$

where ϕ_j is the k-th return time to B_n. Then the process F_n converges a.s. in finite-dimensional distribution to the Poisson point process.

As an application, the author obtained the Poisson limit laws for rational functions.

R. D. Mauldin: *Infinite iterated function systems.*

Infinite iterated function systems consisting of conformal maps (CIFS) is a family $\{\varphi_i\}_{i\in\mathbf{I}}$ of injective and uniformly contractive maps on a compact subset X of $\mathbf{R}^d$ with open set condition and some additional regularity conditions on both φ_i and X.

In this paper, the author gives a thorough survey of the recent theory of the CIFS and illuminates its difference from that of *finite* iterated function systems and also the role of *the topological pressure function* in analysis.

Altogether the book offers a rich variety of contributions on a fashionable subject.

X. Guyon: Random Fields on a Network: Modelling, Statistics, and Applications, Springer-Verlag, 1995

Reviewed by M. Duflo, Marne-la-Vallée

Spatial modeling remains at the crossroads of many topics. From its origins in experimental design for agricultural research (P. Whittle, 1954) and applied, for example in epidemiology, ecology, geography, and economics, it was the focus of increasing interest during the 1980s (J. Besag, H. R. Künsch, B. Ripley and others; in France, X. Guyon and B. Prum). In the meantime, Bayesian statistical analysis for signal processing and inverse problems was attracting more and more interest. The scope of these models increased when S. and D. Geman explained (in 1984) how they provide a general framework for image analysis, thus opening a wide range of statistical and algorithmic research.

It became quite important to publish an up-to-date presentation of the mathematical foundations of this theory. Xavier Guyon's book, first published in French by Masson (1992), was inspired by several graduate-level courses in Paris; the English translation, published by Springer-Verlag, includes new examples given as exercises and new topics on stochastic algorithms.

The first two chapters open the two main tracks of the theory, namely, second order and Markovian fields. Several previous books were mostly dedicated to the second-order track and to specific statistical problems for Gibbs models, e.g., N. Cressie (*Statistics for spatial data*, Wiley, 1991) and B. Ripley (*Spatial statistics*, Wiley, 1981; *Statistical inference for spatial processes*, Cambridge University Press, 1988). But it was difficult to find a general presentation of Gibbs models and Markovian fields with their representation

as a Gibbs field. X. Guyon presents at once both the statistical and probabilistic basis of both theories. Their link is clarified with the aid of Gaussian models: the main part of Chap. 1 is dedicated to Markovian Gaussian fields and mixing properties of Gaussian fields, while the Gaussian specification is given in Chap. 2.

Chapter 3 gives the general asymptotic properties of weakly dependent random fields with recent mathematical tools useful for tackling nonstationary and nonergodic models. General criteria for strong consistency and asymptotic properties of minimum contrast or penalized estimators extending criteria, usually stated under a stronger hypothesis (such as ergodicity), complete this chapter.

On the basis of Chap. 3, the identification of spatial models is studied with its asymptotic properties in Chap. 4 (spectral analysis and Whittle's pseudo-likelihood) and in Chap. 5 (Besag's pseudo-likelihood and recent methods for Gibbsian fields).

The last chapter is an introduction to Markovian stochastic algorithms. A clear and easy theory of Gibbs sampler, Metropolis algorithm, and simulated annealing is given, with basic examples in identification and Bayesian analysis of images. This chapter is a very useful introduction to the recent research on Monte Carlo in image analysis (MAP, MPM, ICM, texture simulation and reconstruction). The reader wishing to go further on this specific topic may read, for instance, D. Geman (*Random fields and inverse problem in imaging*, L.N.M. 1427, Springer-Verlag) and G. Winkler (*Image analysis, random fields and dynamic Monte Carlo methods*, Springer-Verlag, 1995).

To sum up, X. Guyon's book solves a difficult challenge in 250 pages. It opens the way to one of the most up-to-date topics in probability and statistics, with very elegant mathematical proofs and illustrative examples in image analysis. Each chapter ends with bibliographical comments and exercises guiding the reader who wishes to go further. It is a remarkable reference book, useful for anyone wishing to understand the mathematics of random fields keeping close to applications in statistics and image analysis.

D. J. Saville, G. R. Wood: Statistical Methods: A Geometric Primer, Springer-Verlag, Berlin Heidelberg New York, ISBN 0-387-94705-1, 1996, XI/268 pp., DM 68.00, öS 496.40, sFr 60.00

Reviewed by R. Münnich, Tübingen

This book deals with the graphic presentation of statistical methods. The main focus is the derivation of test statistics for paired samples, independent samples, and simple regressions.

In contrast to the sister text, "*Statistical methods: the geometric approach*" by the same authors and publishers, the text here addresses first-year uni-

versity students in statistics and mathematics, as well as their teachers and users of statistics. The aim is to present the underlying ideas as simply as possible, i.e., on the basis of vector methods without using any matrix methods. The book could also be used for an elementary course in linear algebra.

The first chapter reinforces this intention. After introducing the main purpose of the book, the general procedure for the deduction of test statistics is described. For interval estimation, readers are referred to the sister text. The first chapter also contains a "Word to Teachers" that gives recommendations for using the text in lectures.

The structure of the next chapters basically follows the scheme below:

- Basic Idea
- An Appropriate Coordinate System
- Orthogonal Decomposition
- Distribution of the Projection Lengths
- Testing the Hypothesis
- *t*-Test
- Comments

Paired samples are discussed in the second chapter. Sample sizes of two, three, and more than three are distinguished. The third chapter focuses on independent samples for two populations. After introducing the simple case of sample size two, the general case of more than three observations is presented. This approach is also used in Chap. four, where the analysis is extended to several independent samples.

The fifth chapter deals with simple regression. The starting point here is again the easier case of sample size five, before turning to the general case. In contrast to the preceding chapters, the error space for simple regression is not separated in an appropriate coordinate system. This is due to a more sophisticated presentation in this case.

The appendix contains several chapters that deal with presentation of the underlying vector methods, the statistical distributions, and tables. A short description of using simple spreadsheets and regression routines is also stated as well as an alternative presentation of test statistics. The results of selected exercises are also shown in the appendix. The book concludes with references and a detailed index.

This monograph is clearly structured and easy to comprehend. All presentations usually start with examples that help the reader to understand the focus of the tests. Remarkably, many examples follow each chapter in the main text as well as in the appendix.

A few inaccuracies and weak notations are found, like vector multiplication of two column vectors, the mean and variance on p. 16, or the transformation in the *t*-statistic on p. 30. The references could be extended, especially to test theory. The alternative test statistic in appendix D is more suited for advanced

readers and fits possibly better in the sister text. Instead, an extension of the solutions to all exercises and a short introduction to basics in test theory would upgrade the book with respect to potential readers.

Despite these critical comments, the book is a valuable and recommendable monograph. This also holds for lecturers of statistics in applied sciences who want to enrich their lectures with graphic presentations of statistical methods. Advanced readers may prefer the sister text.

Michael Monka, Werner Voß: Statistic am PC – Lösungen mit Excel, Carl Hanser Verlag, München-Wien, 1996, 776 pp., DM 98.00

Reviewed by W. Grölz, Tübingen

Compared with other general computer algebra systems in circulation such as Mathematica or Maple, Excel has undoubtedly the most suitable equipment for statistical purposes. The program for the calculation of tables affords a reasonably easy input and processing of large amounts of data. It offers versatile graphic possibilities and above all it has a great number of special routines and data files which, when handled skilfully, can be used extremely effectively for statistical calculations.

The authors, however, do not restrict themselves to presenting typical examples of perfect solutions or giving smart tips for programming. Their aim is not only to explain Excel thoroughly but also to give the reader, who is required to have no more than school knowledge of mathematics, an introduction to the methods and reasoning involved in statistics and convey a sense of the significance of their results.

They succeed very convincingly in the area of descriptive statistics to which the first section of the extensive text is dedicated. Each section begins with a preamble leading to the subject in hand; examples that are simple to calculate and their varied aspects are reiterated and lead to a general discussion. Excel is used whenever calculation is required.

Introductory reflections on the field of applications of statistics and a presentation of the basic functions of the programme system are followed by a digression on the statistical data and the difficulties involved in keeping it unbiased. For the determination of means, divergence, and concentration coefficients of the total investigation, the graphic processing, the characterization of measure digits, growth rates and correlations, regression calculations, error interpretations and trend surveys, one hardly needs to use more than basic types of calculation. The reader will not be taxed by an explanation of what a semi-logarithmic scale is, nor by the elements of differential calculus. Yet the essential statistical information is apparent.

This restriction presents more problems in the second section which deals with inductive statistics. The introduction to probability spaces is rather

vague. The binomial distribution is introduced combinatorically, the related moments are given without proof. With respect to the normal or chi-square distribution, there is of course no other way possible at this mathematical level. The fact that the already proved Bayes' theorem in the example is applied without reference to the underlying space may irritate an attentive reader.

Yet here too the authors were able to explain intuitively the basic principles such as testing of hypotheses with a given significance and the estimation of quantities and intervals. The reader will be convinced of the importance of the central limit theorem when investigating a random sample survey.

The particular value of this section lies in the abundance of examples, which are described in such detail that a user without comprehensive knowledge of the theoretical background can employ them for his own purposes by using a PC. This applies both to the chi-square independent test and testing of regression coefficients and to the calculus of correlations.

Despite some reservations, I think the authors deserve praise for an overall successful attempt to convey to non-mathematicians not only the practical use of the program and for giving an insight into mathematical concepts and ways of thinking.

In order to enjoy the humour of the text, the reader must be familiar with current German politics and German social structure.

Rässler, Susanne: Stichprobenverfahren bei sukzessiver Auswahl mit unterschiedlichen Wahrscheinlichkeiten im Wirksamkeitsvergleich, Vandenhoeck & Ruprecht, Göttingen, 1996, XIV/156 pp., DM 60.00

Reviewed by H. Stenger, Mannheim

Following the traditional theory of survey sampling, the author considers finite populations of units $1, 2, \ldots N$ with unknown values $y_1, \ldots y_N$ of a variable of interest and known values $x_1, \ldots x_N > 0$ of an auxiliary variable characterizing the size of the units. The objective is to demonstrate the efficiency of varying probability sampling in different modifications.

In the author's description of the method of sampling proportionate to size without replacement (ppswor) the probabilities underlying the first draw are $z_1, \ldots z_N$; subsequent draws refer to units not yet selected, with probabilities derived from $z_1, \ldots z_N$ by adequate normalization. Considered are (1) pps sampling with $z_i = x_i/X$, X the sum of all x_i, and (2) ipps sampling where z_i is fixed in a way to produce inclusion probabilities $\pi_i = nx_i/X$. To determine the z_i-values in case (2), an iterative-dynamic search algorithm is developed. Both modifications are combined with the Horvitz–Thompson (HT) estimator, even if pps sampling with HT estimation is not representative with respect to $x_1, \ldots x_N$ as mentioned by the author. Surprisingly, modification (1) is also used in combination with the Hansen–Hurwitz (HH) estimator.

The (variances and) mean square errors (mse) of these strategies are discussed for five artificial populations of sizes $N = 10, 10, 14, 16, 20$, respectively, and sample sizes $n = 1, \ldots N$. It is worth noticing that the (x, y)-diagrams of all five populations suggest that $y_1, \ldots y_N$ are realizations of random variables satisfying a homogeneous linear regression model with $x_1, \ldots x_N$ as values of the exogeneous variable.

For five further populations of sizes $N = 12, 7, 8, 9, 10$, respectively, only x values are fixed in advance, with the y values resulting from inhomogeneous linear regression models with specified parameters. Consequently, the performance of a strategy is characterized by the model expectation of its mse.

All simulations are well-documented with detailed comments on lots of results and with emphasis on the remarkable changes in efficiency for different sample sizes. Special attention is given to the "strange" behavior of the variance of the HT estimator as a function of the sample size n in the pps case. Uncritical conclusions for larger sample and population sizes are avoided.

The author's comments on the strategy combining pps sampling with the HH estimator are too favorable. This strategy is certainly not attractive because of its bias which does not seem to disappear in any asymptotic sense. In addition, this strategy is not even finitely consistent in Cochran's definition. Note that for population 5, the mse for $n = 20$ $(= N)$ is greater than for $n = 1$.

The present study should be extended to illustrate that (a) ipps designs are most useful in combination with representative estimators, especially in connection with homogeneous linear regression models, and (b) estimators which are representative with respect to $x_1, \ldots x_N$ (as above) and in addition to $1, \ldots 1$ perform well if inhomogeneous linear models are appropriate.

D, Bosq: Nonparametric Statistics for Stochastic Processes, Lecture Notes in Statistics, Vol. 110, Springer-Verlag, New York, Inc., 1996, XII/169 pp., DM 58.00, öS 423.40, sFr 51.50

Reviewed by H. Luschgy, Trier

This book deals with nonparametric density estimation, regression estimation and prediction for stochastic processes both in discrete and continuous time. It presents optimal asymptotic results under mixing conditions and includes recent new developments in this area. The book focuses on the kernel method.

After a synopsis, basic tools covering mixing coefficients, Bradley's coupling result, exponential type inequalities, and limit theorems are introduced.

Chapters 2 and 3 provide results for discrete time processes under various conditions on the mixing coefficients. Chapter 2 discusses kernel estimators for the marginal density. The asymptotic behaviour of MSE and uniform a.s.

convergence with rates is investigated as well as the asymptotic normality of the sequence of estimators. The rates and the limiting normal distribution are the same as in i.i.d. case. An interesting section deals with the asymptotic behaviour of the kernel estimator in some non regular cases. Chapter 3 provides corresponding results for kernel regression estimators and the associated nonparametric predictors. A comparison with classical predictors based on ARMA models is included.

Chapters 4 and 5 present many new results for continuous time processes mainly due to the author. Kernel estimators are introduced and optimal rates of convergence are investigated. The phenomenon of superoptimal rates occurring for processes with irregular paths is discussed. Examples of this type of process are provided by homogeneous diffusion processes. In continuous time, data are often collected by using a (discrete) sampling scheme. The sampling problem is considered in detail.

In summary, this is an interesting and recommendable book.

J. Elstrodt: Maß-und Integrationstheorie, Springer-Verlag, Berlin, 1996, XVI/398 pp., DM 58.00, öS 423.40, sFr 51.50

Reviewed by N. Jacob, Erlangen

We here report on another textbook, written in German, for the usual curriculum in a course on measure and integration theory. The main chapters are:

I. σ-Algebras and Borel Sets, II. Content and Measure, III. Measurable Functions, IV. The Lebesgue Integral, V. Product Measure, Fubini's Theorem and Transformation of Integrals, VI. Convergence in Measure and Integration Theory, VII. Absolute Continuity, and VIII. Measures on Topological Spaces. The last chapter includes also a discussion of the Haar measure. Most of the material is standard and presented in a standard way. However, we very much liked the fact that the author also took much care with those results that are more important in the theory of functions of real variables. These results are often omitted in textbooks in this field which serve mainly as a preparation for courses in probability theory.

The author felt it would be nice to include many historical remarks and short biographies (from E. Borel, J. Radon, C. Carathéodory, F. Hausdorff, G. Vitali, B. Levi, W. H. Young, P. Fatou, H. Lebesgue, G. Fubini, L. Tonelli, F. Riesz, E. Fischer, D. F. Egorov, H. Hahn, O, Nikodym, N. Lusin, and A. Haar). Unfortunately these biographies are almost surely hagiographies. The book includes many nice exercises. In fact, this is one point which distinguishes it from many other (German) textbooks in the field.