THE ANNALS of PROBABILITY

Same And Company

AN OFFICIAL JOURNAL OF THE INSTITUTE OF MATHEMATICAL STATISTICS

Special Invited Paper			
Markov random fields on an infinite tree	387		
Articles			
Exit systems	399 412		
Douglas R. Miller and F. Dennis Sentilles Two dimensional semi-stable Markov processes	424 440		
Adrian Segall and Thomas Kailath	449		
Transience and solvability of a non-linear diffusion equation STEPHEN L. PORTNOY	465		
Nonblock source coding with a fidelity criterion ROBERT M. GRAY, DAVID L. NEUHOFF AND DONALD S. ORNSTEIN	478		
Generalized distribution functions: the σ-lower finite case Gordon Simons	492		
The multivariate central limit theorem for regular convex sets T. K. MATTHES	5 03		
Convergence rates for a class of large deviation probabilities Stephen A. Book	5 16		
Order of normal approximation for rank test statistics distribution JANA JUREČKOVÁ AND MADAN L. PURI Poisson approximation for dependent trialsLouis H. Y. Chen	5 34 5 34		
Short Communications			
Deduction of Wold representation of stationary processes from Cramér representation of second-order processes	54 6		
Passages and maxima for a particular Gaussian process Moshe Ein-Gal and Israel Bar-David	54 9		
Martingale convergence to mixtures of infinitely divisible laws G. K. Eagleson	557		
More on equivalence of infinitely divisible distributions W. N. Hudson and J. D. Mason	563		
Some martingales associated with sample spacings	5 69		

Vol. 3, No. 3-June 1975

THE INSTITUTE OF MATHEMATICAL STATISTICS

(Organized September 12, 1935)

The purpose of the Institute of Mathematical Statistics is to encourage the development, dissemination, and application of mathematical statistics.

OFFICERS

President:

Frederick Mosteller, Department of Statistics, Science Center, Room 603, Harvard University, One Oxford Street, Cambridge, Massachusetts 02138

President-Elect:

Donald L. Burkholder, Department of Mathematics, University of Illinois, Urbana, Illinois 61801

Executive Secretary:

George J. Resnikoff, Dept. of Statistics, California State University, Hayward, 25800 Hillary Street, Hayward, California 94542

Treasurer:

Robert M. Elashoff, M.R. IV-Room 111, University of California, San Francisco, California 94143
IMS Business Office, 1367 Laurel Street, San Carlos, California 94070

Program Secretary:

William L. Harkness, Pennsylvania State University, University Park, Pennsylvania 16801

Editor: Annals of Statistics

I. R. Savage, Department of Statistics, P.O. Box 2179, Yale Station, New Haven, Connecticut 06520

Editor: Annals of Probability

Ronald Pyke, Department of Mathematics, University of Washington, Seattle, Washington 98195

Managing Editor:

Donald R. Truax, Department of Mathematics, University of Oregon, Eugene, Oregon 97403

Membership. Membership dues including a subscription to one Annals and The Institute of Mathematical Statistics Bulletin are \$18.00 per year for residents of the United States or Canada and \$12.00 per year for residents of other countries. Special rates of \$9.00 per year are available to students. Rates in each category are one-third higher for members who wish both Annals as well as the Bulletin. Inquiries regarding membership in the Institute should be sent to the Treasurer of the Institute.

Subscription Rates. Current volumes (six issues per calendar year) of the Annals of Probability and the Annals of Statistics are each \$25.00. Members of the Institute of Mathematical Statistics pay different rates (see above). Single issues are \$5.00. Back numbers of both Annals and the Annals of Mathematical Statistics (Volumes 1 through 43) may be purchased from the Treasurer.

The Annals of Probability, Volume 3, Number 3, June 1975. Published bimonthly in February, April, June, August, October, and December by The Institute of Mathematical Statistics, IMS Business Office, 1367 Laurel Street, San Carlos, California 94070.

Mail to the Annals of Probability should be addressed to either the Editor, Managing Editor or the Treasurer, as described above. It should not be addressed to Waverly Press

PRINTED AT THE WAVERLY PRESS, INC., BALTIMORE, MARYLAND 21202 U.S.A.

Second-class postage paid at San Francisco, California and at additional mailing offices

Copyright © 1975 by the Institute of Mathematical Statistics

EDITORIAL STAFF

EDITOR

RONALD PYKE

ASSOCIATE EDITORS

J. R. Blum		
DAVID R. BRILLINGER		
D. J. DALEY		
D. A. Dawson		
R. M. DUDLEY		
DAVID L. HANSON		
C. C. HEYDE		

Donald L. Iglehart		
J. F. C. KINGMAN		
ULRICH KRENGEL		
M. R. LEADBETTER		
A. W. Marshall		
PETER NEY		
WILLIAM E. PRUITT		

J. SETHURAMAN
L. A. SHEPP
CHARLES STONE
HENRY TEICHER
JOHN B. WALSH
MICHAEL J. WICHURA
N. D. YLVISAKER

Managing Editor

K. J. C. SMITH

PAST EDITORS OF THE ANNALS OF MATHEMATICAL STATISTICS

H. C. CARVER, 1930-1938	WILLIAM KRUSKAL, 1958-1961
S. S. Wilks, 1938-1949	J. L. Hodges Jr., 1961-1964
T. W. Anderson, 1950-1952	D. L. Burkholder, 1964-1967
E. L. LEHMANN, 1953-1955	Z. W. BIRNBAUM, 1967-1970
T. E. HARRIS, 1955-1958	Ingram Olkin, 1970-1972

EDITORIAL POLICY

The main aim of the Annals of Probability and the Annals of Statistics is to publish original contributions related to the theory of statistics and probability. The emphasis is on quality, importance and interest; formal novelty and mathematical correctness alone are not sufficient. Particularly appropriate for the Annals are important theoretical papers and applied contributions which either stimulate theoretical interest in important new problems or make substantial progress in existing applied areas. Of special interest are authoritative expository or survey articles, whether on theoretical areas of vigorous recent development, or on specific applications. All papers are refereed.

CHANGE OF MANAGING EDITOR

Beginning with the July issue of the *Annals of Statistics*, and the August issue of the *Annals of Probability*, the new Managing Editor will be Professor Donald R. Truax, Department of Mathematics, University of Oregon, Eugene, Oregon 97403.

IMS INSTITUTIONAL MEMBERS

AEROSPACE CORPORATION El Segundo, California

THE AMERICAN COLLEGE TESTING PROGRAM Iowa City, Iowa

ARIZONA STATE UNIVERSITY Tempe, Arizona

ARTHUR D. LITTLE, INC. Cambridge, Massachusetts

BELL TELEPHONE LABORATORIES, TECHNICAL LIBRARY Murray Hill, N. J.

Bowling Green State University, Dept. of Mathematics Bowling Green, Ohio

CALIFORNIA STATE UNIVERSITY, FULLER-TON, DEPARTMENT OF MATHEMATICS Fullerton, California

CALIFORNIA STATE UNIVERSITY, HAYWARD, DEPARTMENT OF STATISTICS Hayward, California

CASE WESTERN RESERVE UNIVERSITY, DE-PARTMENT OF MATHEMATICS Cleveland, Ohio

CORNELL UNIVERSITY, DEPARTMENT OF MATHEMATICS
Ithaca, New York

FLORIDA STATE UNIVERSITY, DEPARTMENT OF STATISTICS Tallahassee, Florida

FORD MOTOR COMPANY, ENGINEERING AND RESEARCH LIBRARY Dearborn, Michigan

GENERAL MOTORS CORPORATION, RESEARCH LABORATORIES
Warren, Michigan

GEORGE WASHINGTON UNIVERSITY, DE-PARTMENT OF STATISTICS Washington, D.C.

INDIANA UNIVERSITY, MATHEMATICS DEPT. Bloomington, Indiana

INSTITUTE FOR DEFENSE ANALYSES Arlington, Virginia

INTERNATIONAL BUSINESS MACHINES COR-PORATION Armonk, New York

IOWA STATE UNIVERSITY, STATISTICAL LABORATORY Ames, Iowa

JOHNS HOPKINS UNIVERSITY, DEPARTMENT OF BIOSTATISTICS, DEPARTMENT OF MATHEMATICAL SCIENCES Baltimore, Maryland

KANSAS STATE UNIVERSITY, DEPARTMENT OF STATISTICS Manhattan, Kansas

KNOLLS ATOMIC POWER LABORATORY Schenectady, New York

MIAMI UNIVERSITY, DEPARTMENT OF MATH-EMATICS Oxford. Ohio

MICHIGAN STATE UNIVERSITY, DEPARTMENT OF STATISTICS AND PROBABILITY East Lansing, Michigan

NATIONAL SECURITY AGENCY Fort George G. Meade, Maryland

NEW MEXICO STATE UNIVERSITY, DEPART-MENT OF MATHEMATICAL SCIENCES Las Cruces, New Mexico

NORTHWESTERN UNIVERSITY, DEPARTMENT OF MATHEMATICS Evanston, Illinois

OHIO STATE UNIVERSITY, DIVISION OF STATISTICS Columbus, Ohio

OREGON STATE UNIVERSITY, DEPARTMENT OF STATISTICS Corvallis, Oregon

PENNSYLVANIA STATE UNIVERSITY, DE-PARTMENT OF STATISTICS University Park, Pennsylvania

PRINCETON UNIVERSITY, DEPARTMENT OF STATISTICS Princeton, New Jersey

PURDUE UNIVERSITY LIBRARIES Lafayette, Indiana

RICE UNIVERSITY, DEPARTMENT OF MATHEMATICAL SCIENCES Houston, Texas

THE ROCKEFELLER UNIVERSITY New York, New York

SANDIA CORPORATION, SANDIA BASE Albuquerque, New Mexico

SIMON FRASER UNIVERSITY, DEPARTMENT OF MATHEMATICS Burnaby, British Columbia, Canada

SOUTHERN ILLINOIS UNIVERSITY, MATHE-MATICAL STUDIES Edwardsville, Illinois

SOUTHERN METHODIST UNIVERSITY, DE-PARTMENT OF STATISTICS Dallas, Texas

STANFORD UNIVERSITY, GIRSHICK MEMORIAL LIBRARY
Stanford, California

STATE UNIVERSITY OF NEW YORK, BUFFALO, DEPARTMENT OF STATISTICS Amherst, New York

TEMPLE UNIVERSITY, MATHEMATICS DE-PARTMENT Philadelphia, Pennsylvania

TEXAS TECH UNIVERSITY, DEPARTMENT OF MATHEMATICS Lubbock, Texas 79409 THE TOBACCO INSTITUTE Washington, D.C.

Union Oil Company of California, Union Research Center Brea. California

UNITED STATES ARMY RESEARCH AND DE-VELOPMENT CENTER Aberdeen Proving Ground, Maryland

UNIVERSITY OF ALBERTA, DEPARTMENT OF MATHEMATICS Edmonton, Alberta, Canada

UNIVERSITY OF ARIZONA, DEPARTMENT OF MATHEMATICS Tucson, Arizona

UNIVERSITY OF BRITISH COLUMBIA, DE-PARTMENT OF MATHEMATICS Vancouver, B.C., Canada

UNIVERSITY OF CALGARY, MATHEMATICS DEPARTMENT Calgary 44, Alberta, Canada

UNIVERSITY OF CALIFORNIA, BERKELEY, STATISTICAL LABORATORY
Berkeley, California

UNIVERSITY OF CINCINNATI, DEPARTMENT OF MATHEMATICAL SCIENCES Cincinnati, Ohio

UNIVERSITY OF GUELPH, MATHEMATICS AND STATISTICS DEPARTMENT Guelph, Ontario, Canada

UNIVERSITY OF ILLINOIS AT CHICAGO CIRCLE, DEPARTMENT OF MATHEMATICS Chicago, Illinois

UNIVERSITY OF ILLINOIS, MATHEMATICS DEPT.
Urbana, Illinois

University of Iowa, Division of Mathematical Sciences Iowa City, Iowa

UNIVERSITY OF MANITOBA, DEPARTMENT OF STATISTICS Winnipeg-19, Manitoba, Canada

UNIVERSITY OF MARYLAND, DEPARTMENT OF MATHEMATICS College Park, Maryland

UNIVERSITY OF MICHIGAN, DEPARTMENT OF STATISTICS Ann Arbor, Michigan

UNIVERSITY OF MINNESOTA, SCHOOL OF STATISTICS Minneapolis, Minnesota

UNIVERSITY OF MISSOURI, DEPARTMENT OF STATISTICS Columbia, Missouri UNIVERSITY OF MISSOURI AT ROLLA, DE-PARTMENT OF MATHEMATICS Rolla, Missouri

UNIVERSITY OF MONTREAL, DEPARTMENT OF MATHEMATICS Montreal, Quebec, Canada

UNIVERSITY OF NEW MEXICO, DEPARTMENT OF MATHEMATICS AND STATISTICS Albuquerque, New Mexico

UNIVERSITY OF NORTH CAROLINA, DEPART-MENT OF STATISTICS Chapel Hill, North Carolina

UNIVERSITY OF OREGON, MATHEMATICS DE-PARTMENT Eugene, Oregon

UNIVERSITY OF OTTAWA, DEPARTMENT OF MATHEMATICS
Ottawa, Ontario, Canada

UNIVERSITY OF ROCHESTER Rochester, New York

University of South Carolina, Department of Mathematics and Computer Science

Columbia, South Carolina

UNIVERSITY OF TEXAS, DEPARTMENT OF MATHEMATICS
Austin, Texas

UNIVERSITY OF WASHINGTON, DEPARTMENT OF MATHEMATICS Seattle, Washington

UNIVERSITY OF WISCONSIN, MADISON, DE-PARTMENT OF STATISTICS Madison, Wisconsin

UNIVERSITY OF WISCONSIN, MILWAUKEE, DEPARTMENT OF MATHEMATICS Milwaukee, Wisconsin

VIRGINIA COMMONWEALTH UNIVERSITY, DE-PARTMENT OF MATHEMATICAL SCIENCES Richmond, Virginia

WAYNE STATE UNIVERSITY, DEPARTMENT OF MATHEMATICS Detroit, Michigan

WEST CHESTER STATE COLLEGE West Chester, Pennsylvania

WESTINGHOUSE ELECTRIC CORPORATION, RESEARCH LABORATORIES Pittsburgh, Pennsylvania

YALE UNIVERSITY, STATISTICS DEPARTMENT
New Haven, Connecticut

THE ANNALS OF PROBABILITY

INSTRUCTIONS FOR AUTHORS

Submission of Papers. Papers to be submitted for publication should be sent to the Editor of the Annals of Probability (For current address, see the latest issue of the Annals.) The original (or xerox copy) should be submitted with four additional copies on paper that will take ink corrections. The manuscript will not normally be returned to the author; when expressly requested by the author, one copy of the manuscript will be returned.

Preparation of Manuscripts. Manuscripts should be typewritten, entirely double-spaced, including references, with wide margins at sides, top and bottom. Dittoed or mimeographed papers are acceptable only if completely legible; xerox copies are preferable. When technical reports are submitted, all extraneous sheets and covers should be removed.

Submission of Reference Papers. Copies (preferably two) of unpublished or not easily available papers cited in the manuscript should be submitted with the manuscript.

Title and Abbreviated Title. The title should be descriptive and as concise as is feasible, i.e., it should indicate the topic of the paper as clearly as possible, but every word in it should be pertinent. An abbreviated title to be used as a running head is also required, and should be given below the main title. This should normally not exceed 35 characters. For example, a title might be "A Limit Theorem for Conditioned Recurrent Random Walk Attracted to a Stable Law," with the running head "Limit Theorem for Recurrent Random Walk" or possibly "Recurrent Random Walk Attracted to a Stable Law", depending on the emphasis to be conveyed.

Summary. Each manuscript is required to contain a summary which will be printed immediately after the title, clearly separated from the rest of the paper. Its main purpose is to inform the reader quickly of the nature and results of the paper; it may also be used as an aid in retrieving information. The length of a summary will clearly depend on the length and difficulty of the paper, but in general it should not exceed 150 words. It should be typed on a separate page, under the heading "Summary", followed by the title of the paper. Formulas should be used as sparingly as possible. The summary should not make reference to results or formulas in the body of the paper—it should be self-contained.

Footnotes. Footnotes should be reduced to a minimum and, where possible, should be replaced by remarks in the text or in the references; formulas in footnotes should be avoided. Footnotes in the text should be identified by superscript numbers and typed together, double-spaced on a separate page.

Key Words. Included as the first footnote on page 1 should be the headings:

American Mathematical Society 1970 subject classifications. Primary—; Secondary—. Key words and phrases.

The classification numbers representing the primary and secondary subjects of the article may be found with instructions for its use, as an Appendix to Mathematical Reviews Index to Volume 39, June 1970. (See, also, The Notices of the American Mathematical Society, June 1970, pp. 616-618, for more details.) The key words and phrases should describe the subject matter of the article; generally they should be taken from the body of the paper.

List of Symbols. A completely typewritten list of symbols, identified typographically, not mathematically, should be attached to the manuscript on a separate page. Distinguish between "oh" and "zero"; "ell" and "one"; "kappa" and "kay", etc. Indicate also when special type is required (Greek, German, script, boldface, etc.); other letters will be set in italics.

Figures and Tables. Figures, charts, and diagrams should be prepared in a form suitable for photographic reproduction and should be professionally drawn twice the size they are to be printed. (These need not be submitted until the paper has been accepted for publication.) Tables should be typed on separate pages with accompanying footnotes immediately below the table.

Formulas. Fractions in the text are preferably written with the solidus or negative exponent;

thus, (a + b)/(c + d) is preferred to $\frac{a + b}{c + d}$, and

$$(2\pi)^{-1}$$
 or $1/(2\pi)$ to $\frac{1}{2\pi}$. Also, $a^{b(c)}$ and $a_{b(c)}$ are pre-

ferred to a^{b_c} and a_{b_c} , respectively. Complicated exponentials should be represented with the symbol exp. A fractional exponent is preferable to a radical sign.

References. References should be typed double-spaced and should follow the style:

[5] Doob, J. L. (1944). The elementary Gaussian processes. Ann. Math. Statist. 15 229–282.

In textual material, the format "... Doob (1944)..." is normally preferred to "... Doob [5]..." . Multiple references can be distinguished as "... Doob (1944a)..." . Abbreviations for journals should be taken from Mathematical Reviews Index to Volume 40, 1970, pp. 1683-1702.

Proofs. Author will ordinarily receive galley proofs. Corrected galley proofs should be sent to the Managing Editor of the *Annals of Probability* (For current address, see the latest issue of the *Annals.*)